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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

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Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

MR. STOCKDALE'S REPORT.

MR. STOCKDALE, the Agricultural Adviser to the Secretary of State for the Colonies, made a prolonged tour of the British West Indies and the other British Colonies in the Caribbean area during the first half of 1932, and the results of his observations and enquiries are embodied in a recently published Report* addressed to the Chairman of the Colonial Advisory Council of Agriculture and Animal Health. During his stay in Trinidad, Mr. Stockdale took the opportunity of enquiring very thoroughly into the activities of the Imperial College of Tropical Agriculture which, he points out, is now called upon to perform the following duties:

(*a*) to provide an agricultural training up to diploma standard for residents in the Caribbean area,

(*b*) to undertake advisory work for the Windward and Leeward Islands of the West Indies,

(*c*) to function in a consultative capacity for West Indian Colonies with strong Agricultural Departments, such as Trinidad, British Guiana and Barbados,

(*d*) to provide a post-graduate training under tropical conditions in tropical agriculture and agricultural sciences,

(*e*) to provide for long-range research into problems connected with certain tropical crops.

The first three functions are required for the development of West Indian agriculture, whilst the last two are clearly Imperial in character.

The circumstances that led up to the initiation of the post-graduate course and the gradual formulation of the present curriculum are described and it is stated that evidence has already been received from a number of Colonial Administrators that agricultural officers trained under the scholarship system are better equipped for their duties on appointment, and are enabled to commence with greater confidence the investigation of various agricultural problems than those who have not had the advantage of this training. In point of fact, during the nine years ending June 1932, of the 164 post-graduate students who have been trained at the College, 105 were Colonial Agricultural Scholars and 81 of these are now employed in the Colonial Agricultural Service. The others have obtained semi-Government or temporary employment. With regard to further developments in post-graduate training

* F. A. Stockdale, C.M.G., C.B.E.,—Report on visit to the West Indies, Bermuda, British Guiana and British Honduras, 1932.—C.A.C. 128.

Mr. Stockdale mentions the intention to introduce students to Colonial Agricultural Law, as soon as a comparative summary of the existing legislation has been completed. It is possible that this will not prove so simple as it sounds. The agricultural laws vary a good deal from Colony to Colony, and it will probably be found in the end that it will only be possible to provide a very short summary in Trinidad, while the detailed knowledge will have to be acquired by the new recruit after he has settled down in the Colony to which he is posted.

Mr. Stockdale mentions that the College Farm is still somewhat small but since his visit it has fortunately been found possible to extend the Farm by the acquisition on long lease of a further thirty acres from the Cotton Research Station of the Empire Cotton Growing Corporation.

Diploma teaching is dealt with at some length, and as the result of discussions held by the Academic Board during Mr. Stockdale's visit, the proposal was made to initiate a two-year certificate course, in addition to the existing three-year diploma course. During the period that has elapsed since Mr. Stockdale's visit, this proposal has taken definite shape, and has met with the general and unqualified approval of all the Governments of the British Caribbean possessions. The entrance standard will be slightly lowered, although the age limit has not been lowered, and a curriculum is being designed, which, it is hoped, will meet the special requirements of the sons of planters and of those who definitely hope to make a career on the land in this region. Mr. Stockdale has frequently emphasised in his report the need for better trained men in the personnel of the various Agricultural Departments in the West Indies, and has insisted on the necessity for filling vacancies from the ranks of the diplomates of the College. He has pointed out, however, that such vacancies are likely to be somewhat limited in number and that, therefore, the more empirical training that is contemplated in the certificate course may be more suitable for those students who wish to seek a career on the land.

Mr. Stockdale comments favourably on the extent and nature of the research work that is being carried out at the College. For instance, with regard to the investigations that are being undertaken into the vegetative propagation of cacao and citrus, it is stated that "useful progress is being made which should lead the way to a considerable advance of crop improvement amongst the crops of the tropics". The work is without doubt of Imperial value, and this is also definitely the case with the Low Temperature Research work. In the latter connection the advice of the College has recently been sought in connection with certain difficulties that have arisen in the transport of bananas between Samoa and New Zealand, and experiments are being carried out to discover a solution to this problem. Mr. Stockdale advocates co-operation in banana breeding work between the College and Jamaica. The College authorities have long recognised the need for this co-operation, and more than two years ago when the Principal visited Jamaica, a concordat was drawn up and signed conjointly by himself and the Director of Agriculture, Jamaica. By this arrangement the investigation of crosses between Gros Michel and Robusta will not be undertaken by the College, which will confine its attention to cytological studies and long range research generally. Moreover, the trained cytologist mentioned by Mr. Stockdale in his report has, after spending several weeks at the College and discussing the various problems concerned with the research workers here, now joined the staff of the Jamaica Agricultural Department. This should result in the establishment of cordial relations and the avoidance of overlapping.

Mr. Stockdale's conception of the scope of the research work that should be undertaken by the College is in one respect slightly at variance with Professor Engledow's ideas, outlined four years ago in his report. The latter suggested that a particular crop should be the unit and that long range research at any rate should be confined to four main crops, viz.: cacao, sugar-cane, bananas and limes. Mr. Stockdale is inclined to favour investigation into particular aspects of research. For example, he emphasises the value of the work that is being done on vegetative methods of propagation, and makes the definite suggestion that an interesting piece of fundamental chemical and physiological research for the Imperial College to undertake would be to ascertain the special food requirements of the coconut palm at the stage when it comes into bearing. The coconut is not one of the crops specifically mentioned by Professor Engledow. The difference is not really important, but it should be remembered that there are certain fundamental problems urgently demanding long range research and which can best be undertaken by an institution such as the College. Thus, the best hope of solving a particular problem will probably lie in the utilization of the most convenient crop that is available as an indicator of results.

Mr. Stockdale has some pertinent remarks to make about the College Advisory Department, and it is gratifying to find that in his opinion it has been able to effect material improvement in the agricultural services of the smaller West Indian Islands since its strength was augmented in 1929. He points out, however, that this Department is largely administrative in character, and while admitting that the present system works reasonably well, it is not without difficulties. It is the only possible one under existing circumstances, but the suggestion is thrown out that it might be amalgamated with a combined Agricultural Service for several of the Colonies. A unified Agricultural Service for the West Indies would undoubtedly provide many advantages, but it will not be possible to bring this into effect until some form of Federation is first of all accepted. No doubt the matter will receive the attention of the Commission which is now

reviewing the situation on behalf of the Secretary of State for the Colonies in regard to the possibilities of closer union. The ideal solution would, however, be for the Imperial College to be responsible for teaching and research, and for a unified Agricultural Department, working side by side and in close co-operation, to undertake experimental, demonstration and extension work generally.

Mr. Stockdale has many interesting things to say about the various Colonies which he visited. He is in the unique position of having served in these Colonies 20 years ago, and is, therefore, particularly well able to assess any changes. In his opinion progress has been made in almost all the Colonies and in many of them, he states, this progress is considerable. His report, throughout, contains an urgent plea for co-operation. For example, the position of the Sea Island cotton industry can best be tackled if the West Indies will form a Growers' Association responsible for standardisation in quality of exports and for the enforcement of quota restrictions when necessary. Also, with regard to the newly established fruit and vegetable industry, there is need for a West Indian Producers' Organisation to insist on equivalent standards with regard to quality and packing, and to take up the question of markets. Again, the ultimate aim of the various organizations that have been started in connection with grapefruit and other citrus export trades should be their federation into an influential West Indian Citrus Producers' Association. These ideas are eminently sound and it is to be hoped that they will soon be consummated. There is no doubt that there has been more movement in the direction of co-operation along these lines in the last five years than in the previous fifty. The existing state of the world's markets for agricultural produce coupled with the keen competition is moreover forcing producers in the West Indies to combine as elsewhere, and, through the force of circumstances, they are beginning to realise the true meaning of the old saying "united we stand, divided we fall".

CACAO LITERATURE.

COPIES of the following may be obtained from the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, Trinidad, B.W.I. Price 1s. each.

1. The First Annual Report of the Cacao Research Scheme (1931), 44 pp., twelve diagrams and one plate.

2. The Cacao Soils of Grenada. F. Hardy, J. A. Macdonald and G. Rodriguez. 28 pp. and two maps.

3. The Economic Botany of Cacao. A Critical Survey of the Literature to the end of 1930. E. E. Cheesman. 16 pp.

COTTON NOTES.

The Cottons of Mexico, Guatemala and Colombia.

By F. M. Mauer, Supplement to the Suppl. 47, *Bull. App. Bot., Genet. and Plant Breeding*, U.S.S.R., 1930, pp. 425-464.

In 1925 the Institute of Applied Botany (Leningrad) sent an expedition to Central America in order to collect, among other economic plants, material from the rich and varied assemblage of cottons known to be present in this region. The material was given over to the Turkestan Plant Breeding Station for the further work of botanical and agronomic study.

The report is said to be a preliminary communication, the object of which is to give a description of the material collected by the expedition.

According to the theory put forward by Zaitzev the cultivated cottons of the American Continent fall into two groups (1) a South American sub-group comprising *G. barbadense* L. and its numerous sub-species and varieties and (2) a Central American sub-group comprising *G. hirsutum* L. and a similar complex series of sub-species and varieties.

The first group includes the perennial Kidney cottons, and the Peruvian Marie Galante types (Ishan, Tanguis and West Indian Native), as well as Sea Island, and Egyptian, while the latter group is made to include not only the Upland cottons, but also the large assemblage of Central American Bourbon cottons.

While we may accept the hypothesis of a northern and a southern centre of distribution of New World cultivated cottons, it is not so clear that the Central American group of Bourbons, which extends from Florida through Central America and the Antilles to Brazil, should be merged in the Upland group (*G. hirsutum* L.).

The reviewer has worked on the genetics of the Bourbon group and has expressed the view that this group is entitled to specific rank under the name *G. purpurascens* Poir. We may agree with the Russian workers that the Bourbon group is closely allied genetically to Upland, since crosses are usually fully fertile in both F_1 and F_2.

The occurrence of male sterile forms in an F_2 of Upland x West Indian Bourbon has, however, recently been noted. Our reasons for retaining the specific name *G. purpurascens* are mostly based on ecological considerations, though there is evidence that a number of genes present in the Bourbon group are absent from Upland.

Thus the factor R_2 for red plant body of Bourbon has proved to be identical with the red factor of *G. barbadense*, the red colouration of Upland being due to an independently inherited duplicate gene R_1.

Similarly there are differences in the two groups in respect of the distribution of chlorophyl deficient factors.

Morphologically the Bourbon group also differs from the Upland group in several well marked characters, *e.g.*, in the complete immunity to

Cotton Leaf Blister Mite (*Eriophyes gossypii*, Banks) in the late bursting of the anthers, and in the relative length of the filaments at different positions on the staminal column.

The Bourbon group is closely related to the wild Polynesian species, *G. taitense*, Parl. found in Fiji and it is probable that this species may be the wild prototype of the Bourbon cultivated cottons.

Perhaps the most interesting physiological features of the tropical cottons observed are those connected with photoperiodism. As is well known through the researches of Allard and Garner, certain plants require a long day to initiate a reproductive phase, others a short day. The reviewer found some years ago that the perennial cottons of the tropics refused to flower in a greenhouse in England, and the reason for this is now apparent through observations made in Turkestan. The author states:

"From the investigation of the materials it may be seen that the forms of the tropical belt show a marked adaptation to a short day, which is sufficiently indicative of the fact that they are endemic for the tropics. Only an inconsiderable part of the tropical forms is characterized by a long photo-period. As these forms differ sharply by their morphological characters from the bulk of cottons, it is thought that they have been introduced into these regions in the very last historical period from more northern latitudes, chiefly from the United States and from West India.

"The study of the material collected was greatly complicated, not only by its vastness, but also by the fact that it consists chiefly of tropical forms adapted to a short day. However, by means of an artificially shortened day (first used on a small scale by G. S. Zaitzev) this difficulty could be overcome.

"Under the conditions of the long day connected with our latitudes of Tashkent, an entirely abnormal behaviour of the tropical cotton plants can be observed. The reproductive phase is either much delayed or does not set in at all. The plant grows luxuriantly, reaching a great height, the limbs or vegetative branches are very numerous, while the fruiting branches sometimes do not appear at all before the frosts set in. All vegetative parts, especially leaves and stipules, reach great dimensions and are abnormally strongly divided. The rankly growing leaf blade shows a vesicular surface, thus the whole aspect of the plant sharply differs from a normal one. To study the reproductive organs, the flowers, bolls, seeds and fibre, becomes impossible.

"When the same forms are grown under the conditions of a short (twelve hours) day the behaviour of the plant entirely changes; the reproductive phase sets in considerably earlier, the vegetative development of the plant is much less, all vegetative organs being reduced in number and in dimensions. The height of the plant is less; the monopodial branches decrease in number and dimensions, while the fruiting branches are formed early and at a low height."

By employing a shortened day the Turkestan workers have been able to induce the perennial cottons to flower in the sub-tropics and thereby to effect crosses with Upland varieties. The object of crossing is to render the great genetic diversity of the Central American cottons available for the improvement of Upland and Egyptian cottons. The author states:

"The varietal diversity and botanical composition of the Central American cottons is of profound interest for several reasons.

"Firstly, here is a country with a cotton cultivation of the greatest antiquity, existing long before the discovery of America by Europeans. Moreover, in these regions we have the most ancient areas of the species *G. hirsutum* L. and *G. barbadense* L.

"These countries furnished the world with all that diversity of sorts of Upland and Sea Island on which the cotton industry of the majority of countries of the Old and New Worlds is based. The varietal diversity of the ancient cultivations of the New World is far from exhausted; new sorts of Mexican origin are constantly being found after which they receive general recognition and wide application, *e.g.*, Acala, Durango, &c.

"For this reason it is essential to give serious attention to the study of the varietal wealth accumulated in these countries during a thousand years of cotton cultivation and breeding."

With this point of view every geneticist and cotton breeder will be in entire sympathy, and it is one which the present reviewer has frequently expressed. The Russian botanists are the first to make a systematic exploration of the possibilities of the cottons of Central America. The cotton-growing industry will undoubtedly reap a rich reward.

S. C. HARLAND.

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1. *Empire Cotton Growing Rev.*, 1929.
2. The Cotton Plant in Egypt. London, 1929.
3. *U. S. D. A. Bul.*, 1164, 1923.
4. *Agr. Jour.*, India, 1923.
5. *Trans. Turkest.*, Plant Breeding Station, No. 12, 1928.

COLLEGE MEMOIRS.

The following may be obtained on application to the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

Economic Series:		
No. 1.—The Sugar Industry of the British West Indies and British Guiana, with special reference to Trinidad	C. Y. Shephard	1s.
Sugar Technology Series:		
No. 1.—Cane Syrup	R. H. Hurst	1s
No. 2.—Experiments with Final Molasses	J. A. McDonald	6d.
No. 3.—Sampling of Cane in the Field	J. G. Davies	6d.
Mycological Series:		
A Further Preliminary List of Trinidad Fungi	C. A. Thorold	1s.

MANURIAL EXPERIMENTS WITH SUGAR-CANE.

V.—A NOTE ON THE RESIDUAL EFFECT OF POTASH ON THE YIELD OF FIRST RATOON CANES.

P. E. Turner,
Soil Chemist to the Sugar-Cane Investigation Committee.

I.—Introduction.

In the third paper (4) of this series details are given of four manurial experiments laid down in 1929, on degenerated soils, to determine the effect of treatment with potash on the yield of plant canes. All the plots on the various experimental areas received basic dressings of ground limestone, organic manure (either in the form of pen manure or sheep manure) and sulphate of ammonia. Certain plots were given, in addition, dressings of 2 cwts. of sulphate of potash. The experiments were reaped as plant canes in 1931.

The basic dressing of pen manure, applied to three of the experimental areas, contained approximately 200 lbs. of potash as K_2O. Nevertheless, the additional application of 2 cwts. of sulphate of potash resulted in increments in yield of 5.03 tons, 5.19 tons and 3.53 tons, respectively, of plant canes to the acre. The basic dressing of sheep manure, applied to the fourth experimental area, contained approximately 30 lbs. of potash as K_2O. In this case the plots receiving inorganic potash gave an increment in yield of 4.96 tons of cane. It appears, therefore, that *the potash present in pen manure may be largely unavailable to the plant canes.* Such a conclusion is of the utmost importance, for it is probable that there exist in Trinidad other areas of soil closely similar in nature to those under experiment. Hitherto it has not been the custom in the West Indies to apply to plant canes potash in inorganic form as well as pen manure.

II.—Aim of the Experiment.

There is little specific mention, in the general literature on sugar-cane, as to whether potash, when applied to plant canes, has a residual effect on the subsequent ratoon crops. Definite evidence of this nature is certainly not available in Trinidad. In order to obtain preliminary information in this connection the canes on one of the experimental areas were reaped under supervision as first ratoons. The area which received sheep manure as a basic dressing was selected for the purpose. It has previously been recorded (4) as Experiment B.

III.—Details of Experiment B.

Cane Variety.—Co.213.

Soil Type.—Degenerated river alluvium.

Layout.—

The permanent cane beds were used as plots. Three out of every four beds received sulphate of potash. The remaining beds were not treated with sulphate of potash.

The beds were 25 feet wide by 290 feet long. Each plot was therefore 0.166 acre in area.

(1) Plant Canes.

Manurial Treatment of Plant Canes to the Acre.

(i) Basic Treatments (given to all plots).
- (*a*) 3½ tons of ground limestone.
- (*b*) 2½ tons of sheep manure.
- (*c*) 4 cwts. of sulphate of ammonia (in two applications).

(ii) Potash Treatment (to certain plots only).
2 cwts. of sulphate of potash of 91 per cent. purity.

Yield of Plant Cane to the Acre.

Plots with sulphate of potash —43.16 tons.
Plots without sulphate of potash —38.20 tons.
Increment due to sulphate of potash— 4.96 tons.

(2) First Ratoon Canes.

Manurial Treatment of First Ratoon Canes to the acre.

Two cwts. of sulphate of ammonia applied to all plots. No other manurial treatment was given.

Age of Ratoon Canes on Reaping.—11 months.

IV.—Yield Data for the Residual Effect of Potash on the First Ratoon Canes.

As sulphate of ammonia alone was applied to the ratoon canes, the yield data recorded in Table I give a measure of the residual effect on these canes of the sulphate of potash applied to the plant canes.

Table I.—Residual Effect of Potash. Actual Yields of First Ratoon Canes per Plot, in Quarters of 28 lb. Experiment B.

2 cwts. K_2SO_4 per acre as Plant Canes						No K_2SO_4	
Bed.	Yield.	Bed.	Yield.	Bed.	Yield.	Bed.	Yield.
1	630	3	739	4	820	2	713
6	746	7	673	8	623	5	710
9	643	11	681	12	692	10	634
13	627	14	569	16	598	15	551
17	646	18	630	19	644	20	609
21	624	22	608	24	639	23	598
26	561	27	566	28	552	25	590
29	545	31	622	32	575	30	557
34	583	35	600	36	590	33	652
37	606	39	580	40	614	38	623
41	601	43	614	44	651	42	602
46	626	47	650	48	680	45	637

	Qrs. per plot.	Tons per acre.
Mean Yield from plots with sulphate of potash ..	629.1	47.25
Mean Yield from plots without sulphate of potash	623.0	46.79
Increment due to residual effect of potash ..	6.1	0.46

V.—Discussion and Conclusions.

(1) The increment in yield of 0.46 tons to the acre of first ratoon canes on the plots which originally received treatment with potash is statistically definitely not significant.

(2) The apparent absence of a residual effect may be ascribed to one or more of three main causes:—

(*a*) All the potash applied may be required by the plant cane crop, and no reserve may remain in the soil for the ratoon canes.

Noel Deerr, in the second edition of his book "Cane Sugar" (1) gives a balance sheet of the potash removed from the soil by a cane crop. The data recorded represent average figures for a very large number of analyses of canes of many varieties, grown on soils of widely differing types, under varying climatic conditions. According to the balance sheet, 1,000 tons of cane stalks contain on the average 3,000 lbs. of potash. A plant cane crop of 40 tons to the acre, can therefore remove 120 lbs. of potash from the soil. This does not include the potash present in the leaves, tops and roots, which normally remain on the land. 120 lbs. of potash is approximately equivalent to 2 cwts. of sulphate of potash, *the application actually made to the plant canes of the experimental area*. It is therefore possible to explain the apparent absence of a residual effect on the grounds that the dressing of potash is wholly required by the plant cane crop.

A conclusion of this nature must be accepted with due caution, however, for an individual set of analyses, which characterises the canes of a particular area, can differ very greatly from a general average value based on a large number of areas.

(*b*) That portion of the dressing of inorganic potash which is not used by the plant canes may be fixed by the soil in an unavailable form.

Analyses by Page and Williams (3) of the soils of the classical plots of Broadbalk Field, Rothamsted, suggest that fixation of applied potash by the soil may take place to a considerable extent. A number of other investigators (2) have also indicated the possibility of the conversion of potash in the soil from an available to an unavailable form.

Appreciable fixation of potash in this manner by the degenerated soils of the experimental area is well within the realms of possibility.

(*c*) The potash applied as sheep manure to the experimental area as a whole may have become available during the growth of the first ratoon canes, and, on the plots which were not treated with inorganic manure, may satisfy the need of the canes for potash.

The potash in sheep manure is probably available even to the plant cane crop. In any case, the dressing of sheep manure contains only 30 lbs. of potash, and it is very unlikely that this quantity would be adequate for the needs of the ratoon crop.

(3) *The yield data in Table I suggest that it may in certain cases be advisable to apply inorganic potash to first ratoon canes as well as to plant canes, especially on areas of degenerated soil.* To test these conclusions there are in operation at the present time certain more critical experiments, which are laid down in the form of randomised blocks, and which include plots receiving single, double and triple treatments of potash.

Summary.

(1) Details are given of an estate experiment reaped to determine the residual effect of potash on the yield of first ratoon canes. To the previous crop of plant canes a dressing of 2 cwts. of sulphate of potash was applied. The ratoon crop received no treatment with potash.

(2) In this experiment, potash appears to have had no residual effect on yield. The plots receiving potash as plant canes gave a yield of 47.25 tons to the acre as first ratoons. The plots without potash gave a yield of first ratoons of 46.79 tons. The difference of 0.61 ton is statistically definitely not significant.

(3) The possible causes of the absence of a residual effect of potash on yield are briefly discussed.

(4) It may be advisable in certain cases to apply inorganic potash to first ratoon canes, as well as plant canes, especially on soils of degenerated areas.

Acknowledgments.

The author is indebted to the manager of Trinidad Sugar Estates, Ltd., for permission to publish the data in Table I, and for his interest in these investigations.

References.

(1) Deerr, N. (1921). *Cane Sugar*, Chapter VI, p. 99.
(2) Hissink, D. J. (1922). *Internat. Mitt. Bodenkunde*, XII, p. 81.
(3) Page, H. J., and Williams, W. (1925). *Trans. Faraday Soc.*, XX, p. 573.
(4) Turner, P. E. (1932). Bull. No. 17, *Fourth International Congress of Sugar Cane Technologists*, Porto Rico. *Tropical Agriculture*, Vol. IX, No. 7, p. 206.

ADCO.

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SALINE AND ALKALINE SOILS.

A Summary of Some Results of Recent Researches on their Origin, Genesis and Agricultural Relationships.

By F. Hardy.

The development and application of new means for examining soils (such as precise procedures for measuring soil alkalinity, soil salinity, and exchangeable or surface-combined bases), has elucidated many of the difficult problems associated with the amelioration of infertile saline and alkaline soils, and has almost revolutionised ideas concerning their mode of formation and chemical relationships. The researches of Russian pedologists have added greatly to our knowledge of the natural history and field characters of these soils, while the laboratory studies of American soil scientists, notably those of the California and Arizona Colleges of Agriculture, have done much to explain their chemical properties and behaviour under different treatments. Some of the more important results of these investigations will be considered in their chemical and agricultural aspects in this article.

I.—Distribution.

Saline and alkaline soils are widely distributed in the arid tropics and sub-tropics (9). They occur widespread but are somewhat localised in the South-Western United States of America; Mexico; the Pacific slopes of South America; the western parts of Brazil and Argentina; North and South-West Africa (Sahara, Egypt, Sudan, Kalahari); Central and South-Western Asia (Arabia, Iraq, Persia, Palestine, Afghanistan, Baluchistan and Turkestan), the *reh* lands of India (Rajputana and Punjab); Central and Western Australia, and in numerous smaller areas in other parts of the world, including certain West Indies islands (Cuba, Haiti, Puerto Rico, Jamaica, St. Croix and Antigua). Their reclamation offers some of the most difficult problems that agriculturists have to face.

II.—Classification, Chief Features and Inter-Relationships.

The researches of Russian pedologists have led to the recognition of three main classes of arid soils (20, 21), namely (*a*) Solontshak (saline soils; "white alkali" soils), (*b*) Solonetz; (alkaline soils; "black alkali" soils), and (*c*) Soloti (degraded alkaline soils). A fourth group, (*d*) Rendzinas, may be added to include alkaline non-saline soils rich in calcium carbonate.

(*a*) *Solontshak.*—This title is given to soils that contain large amounts of common salt (sodium chloride), whose presence may be attributed to inundation by sea-water, to decomposition of soda-bearing minerals, or to infiltration from strata rich in salt. They frequently also contain sodium sulphate and magnesium salts. Under dry conditions, salts may accumulate as a white surface efflorescence, but, under wet conditions, the soils may exhibit a high water-table, and thus resemble salt-marsh soils, whose lack of aeration produces characteristic rusty mottling in the lower layers of the soil-profile. Saline soils are usually very permeable to water, owing to the flocculating effect of salts in solution. They are infertile for most crops, but may support a characteristic natural halophyte flora.

(*b*) *Solonetz.*—When Solontshak is subjected to the leaching action of rain or irrigation water containing no salts, profound changes occur, but the final result is largely decided by the presence of calcium carbonate in the soil. Highly acidic, lime-free Solontshak soils, when leached, merely lose salts; there is little tendency for sodium-ion to replace hydrogen-ion in the original soil hydrogen-clay, so that the leached soil is still acidic. Calcareous soils which possess medium or low lime reserves, on the other hand, contain much lesser amounts of combined hydrogen-ion; their exchangeable bases consist mainly of calcium-ion, which in extreme cases, may almost saturate the clay fraction. Under these circumstances, sodium-ion, derived from sodium salts, may displace calcium-ion, and the resulting soils, after the leaching with pure water has removed salt excess, will consist chiefly of "sodium-clay". Sodium clay is notoriously sticky and cohesive, and the leached soils are difficult to till, compact, impermeable to water, and hard to drain; they "run together" when wetted, and the surface dries into a hard layer or pan. Such soils are generally infertile and agriculturally useless.

Furthermore, sodium-clay hydrolyses in the presence of water, giving sodium hydroxide, which imparts a high degree of alkalinity to the soil water. Thus, reaction values between pH 9.0 and pH 10.0 may be realized in calcareous saline soils that have been leached by pure water. During leaching, soluble chlorides disappear first, then sulphates, and finally, if it be present, calcium bicarbonate. This last may combine with sodium hydroxide, generated by hydrolysis of sodium-clay, to produce sodium carbonate ("black alkali") and sodium bicarbonate.

Whereas the soil-profile of Solontshak soils is uniform in appearance, that of Solonetz soils is characteristically stratified. The surface layer, containing the bulk of the soil organic matter, is finely laminated, and the underlying layer is crumbly and cloddy. The subsoil is brownish-grey in colour, very hard and impervious, and exhibits a vertically-cracked columnar or prismatic structure. It contains alkali-soluble humus and sesquioxides, leached down from the surface soil layer, together with deeper-seated accumulations of calcium carbonate, calcium sulphate (gypsum), and various sodium salts.

(c) *Soloti.*—Further profound leaching of Solonetz soils, especially those containing appreciable lime reserves, removes all soluble salts, and eventually brings about the replacement of sodium-ion, combined in sodium-clay, by calcium-ion. The physical properties of the soil are thereby greatly improved, for "calcium-clay" is not sticky, but tractable, permeable, free-draining, open, friable and crumbly. The reaction becomes less alkaline (pH 8.4 or below), and the soil is usually very fertile for many crops. Solonetz soils containing smaller lime reserves may gradually become acidic under continued leaching by water containing carbon-dioxide—combined calcium-ion being progressively replaced by hydrogen-ion. The displaced calcium-ion may first accumulate as concretionary calcium carbonate in the lower soil-layers. The soil-profile at this stage may resemble that of "black earth" (Tschernosem), characteristic of steppe and prairie country. Later, the lime entirely disappears, and the soil becomes "degraded" into an acidic soil type, in which sesquioxides accumulate in the lower layers. Eventually, the sub-surface soil consists of residual silica, bleached white through loss of iron oxides, highly acidic in reaction, and infertile to crops. Such highly-leached soils display a profile which, in extreme cases, resembles that of Podsol, a characteristic soil-type of humid climatic regions.

(d) *Rendzinas.*—These fertile, highly calcareous, non-saline soils exhibit a typical black, humic surface-layer of varying thickness, merging suddenly, through a more or less definite grey or pale-brown transition-layer, with the underlying whitish parent rock (limestone, coral or marl) (20). The surface soil is often heavy and plastic; leaching may have removed much calcium carbonate, so that the reaction may be well below pH 8.4, which represents the degree of alkalinity of a saturated solution of calcium carbonate in carbonic acid.

Continued leaching may change black Rendzina to red "Terra Rossa" soil, as in the uplands of Cuba and Barbados. Typical Terra Rossa occurs in the Mediterranean region; its surface soil is usually acidic.

III.—Agricultural Relationships of Saline and Alkaline Soils.

Much recent research has been directed to an elucidation of the reasons why saline and alkaline soils are so infertile and unproductive, and to means of ameliorating this condition by schemes of reclamation. Formerly, the infertility of these soils was attributed solely to the direct toxic effects on plant-growth of the various salts in solution. It is nowadays realised that moist soil is not simply a mixture of water and inert solid matter, but that the two components interact in a very complicated manner, giving products whose properties and composition depend upon the relative amounts of the interacting components, as well as upon their chemical constitution. A study of the practical significance of this generalisation involves several more or less distinct aspects, which perhaps may best be considered individually.

(1).—Reaction and Concentration Relations.

When alkaline soils are treated in the laboratory with water, the degree of alkalinity developed depends on the extent of the dilution (14). Thus, an extract prepared by mixing one part of soil with one part of water may show a pH value 8.60, but with 20 parts of water, the pH value may rise to pH 9.42, and with 160 parts of water, to pH 8.98 (12). The difference between the first two values represents a seven-fold increase in alkalinity, due entirely to greater soil dilution and hydrolysis. On the other hand, dilution merely lowers the concentration of salts such as sodium chloride in saline soils, and thus renders them less harmless to plants. Hence, the behaviour of saline and alkaline soils depends upon their degree of moistness in the field. Under wet conditions, alkalinity becomes enhanced, but salinity is much decreased, whilst under dry conditions, alkalinity is somewhat diminished, but salinity may attain highly injurious concentrations. The height of the water-table level in saline and alkaline soils is therefore an important factor in their agricultural relationships. It should be given careful consideration when alkali soils are irrigated, for irrigation may raise the water-table and thus increase the alkalinity of the surface soil, or bring up salts from the subsoil.

(2).—Carbon-dioxide Relations.

In our discussion of the chemistry of saline and alkaline soils, it was noted that the first alkali to appear when saline soils are changed into alkali soils by prolonged leaching, is sodium hydroxide, generated by hydrolysis of "sodium-clay" (3). In the presence of excess of carbon-dioxide, sodium hydroxide becomes converted into sodium carbonate, and finally into sodium bicarbonate. These salts (particularly the latter) are much less alkaline than sodium hydroxide, so that carbon-dioxide acts as an alkali corrector. Thus, about three times as much sodium carbonate, and a great many times as much sodium bicarbonate, than sodium hydroxide are required to give an alkalinity of pH 8.65 to their solutions in water. The fixation of alkali as sodium carbonates depends on the carbon-dioxide concentration of the localised soil atmosphere, and this, in turn, depends partly on the quantity of soil organic matter that is undergoing oxidation through the activity of certain soil bacteria. Addition of bulky organic manures and green dressings to alkaline soils should therefore effect beneficial changes. Practical experience (4) amply supports this contention, and organic manures are invariably advocated nowadays for ameliorating alkaline soils. Substances other than carbon-dioxide, however, may serve to reduce soil alkalinity by direct neutralisation. Thus, good results have been obtained by adding powdered sulphur at the rate of 2,000 to 4,000 pounds per acre (14). The sulphur becomes oxidised

into sulphuric acid under the influence of certain soil bacteria. Ferrous sulphate and aluminium sulphate liberate free sulphuric acid when hydrolysed by water; they too often give good results in ameliorating alkali-land. Finally, ammonium sulphate, used as nitrogenous manure, interacts with "black alkali" to form less harmful sodium sulphate, and is therefore sometimes preferable to sodium nitrate in the nitrogenous manuring of alkaline soils, including both Solonetz and non-saline calcareous soils (Rendzina).

(3).—Effect of Gypsum on Alkaline Soils.

The application of gypsum (calcium sulphate)—another corrective for soil alkali—is also a well-established practice. The treatment was first advocated in 1888 by Hilgard (10), who attributed its effect to interaction with sodium carbonate, whereby calcium carbonate and sodium sulphate are formed, so that soluble alkali is replaced by a soluble neutral salt, and thus rendered innocuous. Gypsum is not always effective, however, in reducing soil alkalinity, and it has been shown (1) that, in the absence of carbon-dioxide, gypsum-treated black alkali soil always contains an appreciable undecomposed residue of sodium carbonate. Hence gypsum should be accompanied by organic manures or by sulphur if successful results are to be obtained. Where the soil contains excessive amounts of salts, gypsum has little effect until the salts have first been removed by thorough leaching.

The modern view regarding the action of gypsum on alkaline soils, is that an excess of calcium-ions, derived from this or some other soluble calcium compound, first displaces sodium-ions from sodium-clay, thus rendering the soil more permeable. The liberated sodium-ions and the residual sulphate-ions are then easily leached by watering. Traces of sodium carbonate that may be present in the original alkali soil are not affected by this reaction, so that some other agent (such as carbon-dioxide derived from organic manures) must also be brought into operation in order to produce a neutral soil. In theory, any soluble calcium salt would serve to effect base exchange, but only the cheapest can be used in practice.* Green manuring greatly enhances alkaline-soil improvement by opening up the subsoil by root penetration. Certain green manure crops, such as lucerne, and *Melilotus alba*, *Panicum crus-galli*, *Cynodon dactylon* (Bahama Grass), and other grasses, can tolerate considerable amounts of alkali, and are useful for this purpose.

* The possible employment of *molasses* solution, saturated with burnt or slaked lime so as to form calcium sucrate and calcium salts of the various organic acids occurring in molasses, has suggested itself to the writer; it certainly deserves field trial, at least in sugar-producing countries. Molasses would have the additional advantage as an alkaline-soil corrector, in that its fermentation would liberate considerable amounts of carbon-dioxide.

(4).—Permeability of Saline and Alkaline Soils.

The great difference in permeability between sodium-clay and calcium-clay has already been mentioned. Since the success of irrigation for reclaiming alkali lands depends mainly on the ability of the soil to "take water", the question of soil permeability in relation to the proportionate amount of exchangeable sodium and calcium present has naturally received considerable attention from alkaline-soil investigators. Thus, attempts have been made to establish mathematical expression of this relationship, (Ca/Na Ratio) so that farmers might predict therefrom the behaviour of any soil whose exchangeable-base content has been experimentally determined. Unfortunately, the results obtained have proved disappointing. The following data, obtained by the writer for certain Antiguan soils, suitably illustrate this discrepancy.

Soil (Top 6 inch layer)	Exchange Capacity (mg. equivs.)	$CaCO_3$ Content (%)	Ratio Ca/Na.	Capillary Rise in tubes of soil (Cm. in 5 hrs.)
(1) Greencastle 1	15.4	0.0	91.8	11.2 c.m.
(2) Cedar Valley 2	27.1	39.6	76.6	14.8
(3) Collins 3	24.1	5.9	22.2	12.5
(4) Paynters 1	26.1	0.6	18.1	3.8
(5) Elliots 1	28.2	6.7	10.4	1.8
(6) Cassada Garden 1	30.9	1.0	2.3	0.1

Whilst a general diminution in rate of capillary rise of water as the Ca/Na Ratio decreases is indicated by these data, the relationship is not proportionate nor precise. Other factors, such as initial moisture content, calcium carbonate content, and degree of clayiness, are also involved. Moisture content in the field affects the Ca/Na Ratio markedly (6). Thus, the ratio decreases as the soil loses water; a perfectly dry alkaline soil is extremely hard and highly dispersed. On the other hand, thorough leaching (if such can be properly accomplished) increases the Ca/Na Ratio by removing sodium-ion through hydrolysis and solution. Calcium-ion takes its place, and the soil gradually becomes permeable, although the change is not marked until the last traces of exchangeable sodium have been eliminated (6). As the American alkali-land farmers put it, "a very little alkali is all too much".

There is another factor, in addition to exchangeable sodium, that greatly affects the permeability of alkali soils; it is the formation, precipitation and accumulation of colloidal hydrous alumina and alumino-silicates within the soil, which lead to its "freezing up" or congelation (15).

When pure aluminium-salt solutions are rendered alkaline by addition of sodium hydroxide, precipitation of hydrous alumina occurs at reaction

values lying between about pH 5.0 and pH 8.5. Above pH 8.5, the precipitate is increasingly dispersed, forming more or less soluble sodium aluminates (8). This satisfactorily explains the heavy downward leaching of soluble alumina in highly alkaline soils. As leaching proceeds, soil alkalinity is gradually diminished. When the reaction of the subsoil has been lowered within the insolubility range of alumina (pH 8.5 to pH 5.0), alumina will be precipitated as a highly gelatinous substance that effectively seals the subsoil, and completely prevents the passage of water. Within the subsoil zone, soluble alumina might sometimes interact with soluble silica, presumably brought down through the operation of similar or other agencies, and mutual precipitation may occur, with the concomittent formation of gelatinous alumino-silicates * (7).

It is difficult to prescribe field procedures that would counteract these results. One method, however, has been suggested (15), namely alternate drying and wetting, which is known from laboratory experience, to effect a gradual irreversible dehydration of colloidal alumina and alumino-silicates. Hence deep cultivation and under-drainage, coupled with alternating dry fallowing and wetting (utilising rainfall or irrigation water), may prove very efficacious if persistently practised. The procedure could at least be applicable to restricted areas, such as "slick spots" or "gall patches", which abound in alkali-soil regions. Furthermore, aluminium salts, such as alum, applied to alkaline soils under suitable conditions, appear sometimes to improve their physical state (15). Whilst there is some practical evidence supporting this contention, the results appear not to be lasting, and the explanations offered are obscure.

(5).—Reclamation by Irrigation.

There is only one practical way of reducing the salt content of saline and alkaline soils, namely, by flooding and draining. Where the salts consist of the sulphate, chloride and nitrate of calcium, little difficulty is experienced in reclamation. Where the salts are mainly sodium salts (chloride and sulphate), irrigation with water rich in soluble calcium compounds is also usually effective, but irrigation with *pure* water invariably ends in failure, the soil rapidly becoming impermeable and no longer "taking water" readily. An adequate dressing of gypsum applied to these soils may sometimes alleviate the trouble, as has already been indicated, but usually the quantity of gypsum required is relatively great. Irrigation with water containing sodium salts, even in small amounts, eventually is harmful, and should be avoided. Seepage of saline water from higher levels must be prevented during irrigation. The likelihood of injury through irrigation and seepage depends partly on soil texture, a well-drained sandy soil being less susceptible than a badly-drained heavy soil (21).

(6).—Nutrient Relations.

(*a*) *Phosphate.*

Alkaline soils, including normal highly calcareous soils (Rendzina), yield large amounts of phosphate to extracting agents, such as various dilute acids, usually employed for its assessment in laboratory studies. Nevertheless, crops grown thereon generally show marked response to soluble phosphatic manures (acid super-phosphate; Nicifos; Ammophos), but rarely show response to *insoluble* phosphatic manures (rock phosphate, basic slag, bone-meal) (2). Failure to respond has been attributed in most instances to lack of carbon-dioxide in alkaline soils (especially "black alkali" soils) containing insufficient organic matter, and insufficiently aerated (2). Soil water-extracts or the soil solution, expressed from alkaline soils by suitable displacement methods, seldom show more than traces of phosphate (1 to 3 p.p.m. of solution) (16). The high solubility of soil phosphates in acidic reagents indicates that phosphate will be readily transferred to the soil solution, provided a sufficiently low pH value is attained (for example, pH 6.2 or 6.4). Phosphate solubility diminishes as pH value rises; at reaction values between pH 8.0 and pH 8.5, phosphate is almost insoluble, and may exist in alkaline and calcareous soils chiefly as a specific calcium phosphato-carbonate compound (17). In the presence of hydrous alumina, phosphate may also suffer fixation as an alumino-phosphate compound, but this is much more insoluble in normal calcareous soils than it is in black alkali soils whose alkalinity reaches high magnitudes (19). Sodium salts that occur in many alkaline soils and in saline soils depress the solubility of phosphates, and leaching, accompanied by thorough drainage, will therefore often improve the phosphate status of these soils (16).

The phosphate-supplying ability of a soil (*i.e.*, its capacity for maintaining an adequate rate of delivery of phosphate to plants), varies with soil conditions (including soil reaction), but it is also influenced by plant growth-processes. Thus, solvent root excretions, particularly carbonic acid, increase the availability of soil phosphate in the immediate vicinity of plant roots (by reducing the reaction to about pH 6.2 or 6.4) and rapid root absorption lowers the phosphate gradient, so that phosphate uptake may reach adequate magnitude, even in somewhat alkaline soils. Any factor (for example, decomposing organic manure) that increases the carbonic acid content of the soil surrounding plant-roots may aid in the solubilising process. Nevertheless, plants seem to differ in the "feeding power" of their roots, for some species are apparently able to abstract more phosphate from an alkaline or calcareous soil than others.

The phosphate relations of highly alkaline unproductive soils (black alkali soils) are peculiar. Although soil phosphate is insoluble within the

* The peculiar, highly colloidal sodium-clay known as Bentonite (a hydrous alumino-silicate) may owe its formation to this process. The writer has recently discovered Bentonite in Antigua, B.W.I., within a region of highly alkaline unproductive soil.

reaction range pH 8.0 to 8.5, it readily dissolves at reactions higher than pH 8.5, probably through the formation of sodium phosphates (17). Reclamation of these soils by cultivation and irrigation does not at once reduce their high content of soluble phosphate, and crop-plants may utilise it, provided other conditions are favourable to normal root absorption. Eventually, however, the re-solution of residual phosphate may become negligible, and fertility may diminish accordingly.

Quite apart from its affect on the solubility of phosphate, soil reaction appears to exert marked influence on the process of absorption of phosphate by plant-roots (5). Evidence has been adduced from water-culture experiments which demonstrate that little phosphate absorption by plant-roots actually takes place at reaction values above pH 7.6, except in those cases where the diffusion of carbon-dioxide is sufficiently rapid adequately to reduce alkalinity in the region of root contact (5).

This observation is in accord with earlier results (11) which have indicated that hydroxyl-ions are increasingly injurious to plants at concentrations represented by reaction values greater than about pH 8.2.

(*b*) *Nitrate and Potash.*

The results obtained for phosphate absorption by plants placed in media of different reaction values, have been closely reproduced for nitrate and potash absorption under similar circumstances (5, 11). Alkaline reactions apparently greatly depress the absorption of nitrate and potash, as well as phosphate, so that, without the aid of carbon-dioxide within the root-zone, plants cannot obtain adequate supplies of these nutrients from highly calcareous soils and alkaline soils. Whether they can absorb and utilize ammonium-ion under these conditions, however, seems not yet to have been determined.

IV.—Summary and Conclusions: Causes of Infertility in Saline and Alkaline Soils.

During recent years, there has been a marked tendency to stress more and more the profound deleterious effects of "black alkali" on the physical properties of alkaline soils in the field, and to minimize its direct toxic action (4). Detailed studies have demonstrated that, with the usual degree of moistness that obtains in field soils, and near the wilting point of plants, soil alkalinity is seldom excessive (3), even though laboratory examination, under imposed conventional conditions, may indicate high reaction values. When black alkali soils are subjected to thorough leaching by irrigation and drainage, and are afterwards adequately tilled, dressed with gypsum, and treated with organic manures, their fertility generally improves, and satisfactory crops may be grown on them. Their high reaction values are thereby reduced, at least within the root zone, to magnitudes below the limits of alkali tolerance (pH 7.6 or 7.8). The chief agency producing this result is apparently carbon-dioxide, generated by the decomposition of soil organic matter under suitable conditions of aeration.

In the case of saline (white alkali) soils, circumstances are somewhat different. Under low moisture field conditions, salts may become concentrated in the soil water until the limit of tolerance is reached, where plants fail to grow because of the operation of osmotic and dehydrating effects. The toxic limit in most cases of crop-plants appears to lie in the region of 1,000 parts of common salt (and less than 1,000 parts of sodium sulphate) per million parts of soil-solution. For field soils, containing some 20 per cent. of "free" water, this value represents about 5,000 parts per million of *oven-dry* soil. Even though the surface soil may not contain salts in toxic concentration during moist conditions, desiccation may raise highly saline subsoil-water into the root-zone. This effect, however, seems also to have been over-estimated, for direct evidence has accumulated in recent years which indicates that capillary uplift is only effective when the water-table lies within 2½ feet of ground level for heavy-loam soil, and 1 foot for coarse sandy soil (13).

The nutritional disorders accompanying alkalinity in alkaline soils, especially calcareous soils, have lately received special consideration. Recent investigations have demonstrated that, under alkaline conditions (pH values greater than about pH 8.0), soil phosphate is immobilised as insoluble compounds involving calcium carbonate and alumina. Highly calcareous soils may also fix iron oxide and manganese oxide, so that plants growing thereon may suffer marked chlorosis, through lack of adequate chlorophyll formation.

The uptake of nutrient-ions (phosphate, nitrate, potash) by plant-roots is greatly reduced when the alkalinity of the soil solution exceeds magnitudes represented by pH 7.6 or pH 7.8. In highly alkaline soils (reaction values above pH 8.5), aluminium may exert direct toxic action through the formation of aluminates.

It is evident, therefore, that the main factor responsible for the infertility of alkaline soils is their unfavourable reaction. Soils whose reaction values lie above pH 7.8 or pH 8.0 should be regarded with suspicion, and suitable steps should be taken to reduce their alkalinity. In the case of *saline* soils, uncomplicated by reaction effects, mere removal of salt excesses by leaching should prove effective in their amelioration.

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THE CONTROL OF SCAB DISEASE (*Sporotrichum citri*, Butler) IN THE BRITISH WEST INDIES.

By H. R. Briton-Jones, D.Sc.

Large quantities of sour orange seedlings are raised annually in Trinidad, Dominica and St. Lucia as stocks for grapefruit, West Indian limes, and other citrus fruits. The main difficulty with which both planters and Agricultural Departments have had to contend is Scab disease. Whereas some localities are free from this disease, in others it seriously affects sour orange seedlings before they can be used for budding purposes. Where the disease is severe it markedly checks growth and in a large percentage of the attacked plants the tender tissues of the apical buds are killed or so seriously affected as to make it impossible for the leading shoot to make any further growth. The cessation of growth of the apical bud of a diseased plant is followed subsequently by the development of the axillary buds into side shoots and the production, thereby, of a dwarfed and bushy plant with small leaves instead of an upright and vigorous single-shooted plant, suitable for budding. Each of the dwarfed and bushy plants may, however, be converted into a single-shooted one by careful selection of the most vigorous and best placed shoot as leader and by removing all others flush with the main stem. In a nursery badly attacked by Scab this operation must be done at frequent intervals during the life of the young stock, and, if properly carried out, is by no means cheap, since it would be false economy indiscriminately to select the uppermost side branch which may be far weaker than another growing from a point lower on the stem. Moreover, diseased plants are more brittle than healthy ones and the removal of side shoots requires a certain amount of care to avoid breaking the main stem.

In addition to the trimming and selection of side shoots, spraying with Bordeaux Mixture of two per cent. strength is carried out particularly on Government Experimental Stations. This is done once every fortnight and although this practice is claimed to be fairly effective it is generally agreed that the preparation and application of the spray is both troublesome and costly. Moreover, good Bordeaux Mixture is very difficult to prepare in the British West Indies as freshly burnt lime which is necessary for the preparation of this fungicide is not easily obtainable. Burgundy Mixture is, on the other hand, easier to make than Bordeaux Mixture since both the Copper Sulphate and Washing Soda are readily procurable and can be dissolved in water overnight ready for mixing and spraying on the following day. The formula for Burgundy Mixture of one per cent. strength is 5 lb. Copper

Sulphate, 6¼ lb. of Washing Soda and 50 gallons of Water. Burgundy Mixture is an excellent fungicide and it adheres well to the sprayed parts of plants. The practice of spraying with Bordeaux Mixture in preference to Burgundy Mixture is a gamble in moist tropical climates because of the uncertainty of the quality of the former fungicide.

No explanation of the localised distribution of Scab disease in Trinidad and other West Indian Islands can at present be given with any degree of certainty. Pellier and Frederick (2) in their work on the Scab fungus stated that "the three essentials for successful infection of citrus plants by *Cladosporium citri*, under controlled conditions, are the presence of free moisture, young growth, and temperature between 15°C. and 23.5°C. (59°F. and 74.3°F.). The optimum for the best development of Scab appears to be about 20°C. and 21°C. (68°F. to 70°F.)". The factor of young growth need not be considered here since it is common to plants growing in both affected and disease-free localities. The factors of greatest importance are the moisture and temperature relationships. Soil factors are not of prime importance though intrinsically rich, or manured and well-cultivated soil has its beneficial effect in that it is conducive to more rapid and continued growth of the plants which are consequently more tolerant of attack and recover quicker with the advent of the dry season when the amount of disease appreciably diminishes.

In a previous note (1) on Scab disease the writer stated that in one locality of the Aripo Valley, where sour orange is grown for nursery work, the disease occurs to such a slight extent that it ceases to be of any importance. Since then it has been observed that sour orange seedlings grown in the Sangre Grande District are also not affected by Scab. On the other hand this disease has year after year consistently caused much damage at the St. Clair Experiment Station as well as in the plots of the Botanical Department of this College. Likewise, the new nurseries established by the Department of Agriculture of Trinidad and Tobago at the St. Augustine Experimental Station as well as commercial nurseries in other parts of the island are seriously affected though a determined effort has been made at the former by Mr. R. O. Williams, the officer in charge, to combat the disease by trimming and spraying at regular intervals. It is not possible to obtain detailed rainfall and temperature curves for all these districts and it is doubtful whether anything more significant than the general truth already known would be gleaned from them, even if they were available. The rainfall at the St. Augustine Experiment Station and the College is approximately the same, being in the region of 60 inches per annum and for the present purpose the distribution of this rainfall, the night and day temperatures throughout the year, and the height above sea level are comparable. On the other hand, the rainfall at Sangre Grande is considerably higher amounting to 100 inches per annum. This means that the average temperature during the wet months is lower in the Sangre Grande district than at the St. Augustine Experimental Station and the College. Similarly the rainfall at Aripo ranges between 100 and 120 inches per annum, the temperature being considerably cooler on this account. In addition, Aripo is approximately 1,000 feet higher above sea level than the other districts mentioned. The weather conditions and the incidence of Scab disease at the St. Augustine Experimental Station and the College when compared with those at Sangre Grande stimulated the writer to attempt to modify the environmental factors on a small area at the College, bringing them more closely into line with those at Sangre Grande since it was not possible to effect in the opposite direction a change of conditions, even on a small scale in the open field, to approximate the drier climate of the dry season when the disease is of no material consequence in any part of the island. In other words, it is more practicable appreciably to augment the effect of a rainfall of 60 inches per annum than to diminish it. The method adopted for the purpose was to grow the young sour orange seedlings under artificial shade. This was used in the preliminary experiment not with a view to recommending its use in preference to shade from living plants, should the treatment succeed in controlling Scab disease, but rather to investigate the effect of shade as a single factor without introducing the additional complication of root interference between the shade plants and the shaded crop.

The lay-out of the experiment consisted of eight rectangular plots each 30 feet long by 8 feet wide. The plots were marked out in line and separated from each other by a distance of eight feet to eliminate interference of the shaded with the unshaded. Each alternate plot was shaded artificially by covering it with coconut leaves, which were supported by wooden uprights and bamboo cross-pieces, at a height of four feet six inches above the ground. Throughout the eight plots alternate rows of sour orange seedlings and ginger rhizomes were planted at the beginning of August, 1932. Five sour orange plants and five sections of ginger rhizomes were planted in a row at intervals of 12 inches with 18 inches between the rows. All plots were liberally manured with blood meal and later with Sulphate of Ammonia. The same amount of manure was given on each occasion to all the eight plots in the Experiment. Ginger was included in the experiment in order (i) to see the effect of shade on the Leaf Spot disease (*Colletotrichum zyngiberae*) which so seriously affects ginger crops grown in the open in Trinidad and (ii) that the double cropping would further contribute towards the desired direction of increased humidity of the atmosphere around the sour orange seedlings. 70 sour orange seedlings and 75 ginger rhizomes were planted in each of the eight plots so that 560 sour orange plants and 600 ginger rhizomes were planted in all.

By the end of September, 1932, it was evident that both the sour orange and ginger plants grown in the shade were markedly free from Scab and Leaf Spot disease whereas the plants in the unshaded plots were badly affected by their respective diseases.

Observations on Sour Orange.

On the 14th October, 1932, observations were carried out to ascertain the number of plants which had failed and the number which had produced side branches and therefore required trimming.

The result was as follows :—

No. of Plot.	Treatment.	No. of dead or missing.	No. trimmed.	Percentage of total trimmed.
1	Shaded	Nil	29	33.6%
3	do.	1	19	
5	do.	Nil	18	
7	do.	1	28	
2	Unshaded	Nil	55	67.5%
4	do.	1	46	
6	do.	1	51	
8	do.	1	45	

It should be noted that all the above sour orange seedlings were seriously affected with Scab at the time of planting and there is no doubt that had those grown under shade been shaded at an earlier stage the figure 33.6 per cent. in the above table would have been considerably reduced. Further observations taken on the 22nd November, 1932, revealed that 73 per cent. of the unshaded plants required trimming as against 16 per cent. of the shaded plants ; the average height of the unshaded and shaded being 16.1 cms. and 25.7 cms., respectively. These figures support the foregoing conclusion in regard to shading the plants early in their life. Only a small number of the shaded plants were affected at all by Scab disease and these but slightly. In each case the presence of the disease in the shaded plots was associated with a thinning of the shade above the affected plants.

It has been definitely established that shading young citrus seedlings is completely effective as a means of controlling Scab disease in nurseries and that much of the cost of establishing the shade either artificially or by means of living plants is markedly reduced owing to the fact that the shade checks the growth of noxious weeds like nut grass (*Cyperus rotundus*) and therefore reduces the cost of weeding. Furthermore, observations on these plots indicated that heavy and continuous shading is not necessary before effective control of Scab disease can be obtained. It was intended to eliminate from the experiment those plants which were at the extremities and sides of the shaded plots since they would, at certain times of the day, be exposed to the sun. Although a few of these became very slightly affected, the result indicates that a further experiment should be carried out to determine the depth and minimum duration of shade necessary per diem to affect the control of Scab. Such an experiment is now in progress where living plants are used as shade since it is cheaper to grow shade plants than to erect a scaffolding for artificial shade.

It is interesting to note that, following a suggestion by the writer, Capt. Stebbings of Dominica has had very good results using Guatemala grass (*Pripsacum taxum*) as side shade. Similarly, several planters in Trinidad are meeting with success using gliricidia, cassava, bananas, papaw and other plants as shade. It is not possible to recommend the use of one or more shade-producing plants in preference to others at the present time but the following points are worthy of the attention of all those whose aim it is to raise robust sour orange stocks :—(*i*) the nursery should be established on the best soil on the estate; (*ii*) both the nursery plants and, when necessary, the shade plants should be manured ; (*iii*) the shade plant used should be of a type that can be ratooned since the shade should be thinned about a month before the time at which budding is to be done. This will gradually harden the stocks preparatory to the cutting down of the shade altogether at the time of budding. The latter is necessary to avoid bud failures and the dying back of young scion shoots when they grow out ; (*iv*) after budding, the shade should be kept at its minimum so as to produce young trees which will not suffer a serious check when transplanted into their permanent position in the citrus grove.

The writer wishes to thank Mr. A. K. Briant, for supervising the planting and all cultural operations in the experiment and for the keen interest he has shown in the work.

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SYNTHETIC QUININE SUBSTITUTE.

Recent work at the University College of Science, Calcutta, has been carried out in an endeavour to synthesize a compound which might replace quinine, the production costs of which are very heavy. It is now reported that Professor H. K. Sen and Professor W. Basu have obtained a substance in the laboratory which on testing has been found to be a good substitute for quinine. Whilst having the same anti-parasitic value, it has the advantage of not producing the side effects associated with quinine, and the taste in water is not so bitter. The compound is an ammonium salt obtained in work on coal-tar derivatives, and it is stated to be moderately soluble in water.—(*Chem. and Ind.*, Vol. LI., 1932, No. 43, p. 884.)

EMPIRE COTTON GROWING.

Production and Consumption.

By John A. Todd, M.A., B.L.

In an article* under the above title the writer reviewed in June, 1931, the progress of Empire cotton, and discussed the place which it had made for itself in the world's cotton supplies and consumption, pointing out that "the present abnormal conditions of cotton supply and demand make such a survey a very disturbing business". By the time that article appeared the conditions had become still more abnormal and disturbing, as the result of the conviction forced upon a very unwilling trade that in spite of reduced acreage the American crop of 1931 was going to be almost record breaking. Actually the ultimate yield of 17,096,000 bales was not far short of the previous record figure in 1926, but the yield per acre was a great deal higher than in that year, 201.2 lb. against 182.6 lb., and was actually the highest since 1914 when the boll weevil had only covered about half the belt. This surprising yield was due to an unprecedented combination of favourable weather conditions throughout the whole season, which incidentally also produced a crop of very much better quality that anything the United States had seen for some years, the average staple length of the crop as a whole being about one-sixteenth of an inch more than in any recent year, and that is quite a serious matter.

The results of this revolutionary change in the whole character of the crop were very important. Coming on top of the then existing conditions (as described in the previous article) of ample stocks and reduced demand, the weight of this enormous crop was bound to reduce prices still further. As it turned out the world had not even then touched the bottom of the great depression which began with the Wall Street crash in October, 1929. In America itself for example, the consumption in August, September and October, 1931, had shown a marked improvement on the figures of the same quarter of the previous season, but this recovery was not maintained and throughout the remainder of the season the consumption figures dropped steadily until those for the last quarter fell away altogether and actually the consumption in the last month of the season (July, 1932) was the lowest on record for any month since these statistics were begun in 1912. The effect on prices was inevitable. Cotton prices in Liverpool had of course taken an upward turn when England went off the gold standard in September, 1931, and from that date New York prices were the only index of what may be called the "gold price" of cotton, for America was practically the only cotton producing country that remained on the gold standard, and on 9th June, 1932, near month futures in New York touched the lowest point on record, 4.85 cents against the previous low record of 4.98 on 4th November, 1898.

This fall in the price of American cotton had very striking results. In 1930‡ the writer pointed out the effect of the low quality and comparatively high price of the American crops of 1927, 1928 and 1929 in forcing the world to substitute Outside Growths for American. This came to a head

Table I.—World's Cotton Consumption.—American *vs.* Outside Growths.

Running Bales 000's.

Season	American.†		Total.	U.S.A.	Outside Growths.		Per cent. on American.
	U.S.A.	Rest of World.			Rest of World.	Total.	
1926-27.							
1st Half	3,284	4,137	7,421	117	5,190	5,307	71.5
2nd do.	3,596	4,760	8,356	135	4,920	5,055	60.5
1927-28.							
1st Half	3,467	4,761	8,228	126	4,636	4,762	57.9
2nd do.	3,068	4,111	7,179	110	5,262	5,372	74.8
1928-29.							
1st Half	3,300	4,308	7,608	113	5,142	5,255	69.1
2nd do.	3,478	3,980	7,458	132	5,419	5,551	74.4
1929-30.							
1st Half	3,152	3,926	7,078	132	5,987	6,119	86.4
2nd do.	2,651	3,286	5,937	117	5,950	6,067	102.2
1930-31.							
1st Half	2,372	2,901	5,273	77	5,809	5,886	111.6
2nd do.	2,712	2,916	5,628	78	5,616	5,694	101.2
1931-32.							
1st Half	2,568	3,549	6,117	53	5,360	5,413	88.5
2nd do.	2,179	4,023	6,202	47	4,543	4,590	74.0

* *Tropical Agriculture*, Vol. VIII, No. 9, pp. 240-244.

† Excluding linters.

‡ Cotton Prices. *Tropical Agriculture*, Vol. VII, No. 12, pp. 326-331.

in the second half of the season 1929-30 when for the first time in history, according to the Federation's returns, the world's consumption of Outside Growths was actually more than that of American. This tendency was carried still further in the first half of 1930-31 when, as will be seen from Table I, the excess consumption of Outside Growths was 11.6 per cent. But the second half of that season saw the beginning of the reaction, and as the result of the huge crop in 1931 the position swung back to something like normal again in 1931-32, especially during the second half of the season.

The most striking feature of this reaction was that it was largely confined to one section of the cotton world, the Far East. In 1931-32, as will be seen from Table III the consumption of American cotton in Asia (India, China and Japan) was nearly double the figure of 1930-31, while their consumption of Indian and Foreign Sundries fell off by almost the same amount. This is of course nothing new, for these countries have always shown great readiness to transfer from American to their local crops or *vice versa*, when relative prices made it worth while although the tendency has never before been shown to such an extent. The result was that in spite of the reduced consumption in the United States the world's consumption of American cotton rose from 10,901,000 bales in 1930-31, to 12,319,000 in 1931-32. Even this was nearly 5 million bales less than the crop, with the result that the carry-over at the end of July, 1932, was raised to the record figure of 12,818,000 bales.

Once more, the American crop showed its infinite capacity for jumping from one extreme to another. In 1932, the acreage was again reduced, though not very materially, but climatic conditions were in almost every respect the reverse of 1931. It is already clear that the crop will be only about 12 million bales. By the time this article appears it will be possible to form some idea of how the season's consumption is progressing. At the date of writing (November, 1932) it is only possible to say that from the record low level of July, the U.S.A. consumption has taken a marked upward turn, and the figures for the first quarter of the season showed a total actually higher than the first quarter of 1931-32, which, as already mentioned, was the best quarter of the year. Garsides' estimates show a similar improvement for the rest of the world, and if that improvement is maintained this season's consumption should be not less that 13 million bales, which would mean at least some reduction at the end of the season from last year's enormous carryover.

Table II.—World's Cotton Crops—distinguishing Empire.

BALES OF 500 lb.—000's omitted.

	1926-27	1927-28	1928-29	1929-30	1930-31	1931-32	Estimates 1932-33
World's Total	**30,373**	**25,719**	**28,512**	**28,388**	**27,702**	**29,176**	**25,041**
U.S.A. Lint	17,977	12,956	14,478	14,825	13,932	17,096	11,947
Linters	1,158	1,016	1,282	1,241	986	**1,000**	**850**
China	1,707	1,833	2,114	1,995	2,456	1,750	2,400
Russia	785	994	1,174	1,279	1,589	1,851	2,000
Egypt	1,727	1,219	1,602	1,697	1,589	1,313	894
Brazil	490	480	511	564	470	556	550
Peru	243	241	220	266	225	213	215
Argentine	65	103	129	138	125	175	175
Other Outside Growths	902	642	846	807	789	781	660
Empire							
India*	5,024	5,963	5,782	5,243	5,224	4,064	5,000
New Fields	295	272	374	333	317	377	350
Empire Total	5,319	6,235	6,156	5,576	5,541	4,441	5,350
Per cent. on World's Total	17.5	24.2	21.6	19.6	20.0	15.2	21.4
	DETAILS OF EMPIRE NEW FIELDS IN 400 lb. bales.						
Sudan	148,118	126,115	161,536	157,769	120,310	234,744	
East Africa	160,032	160,163	245,090	168,603	219,446	210,948	
Rhodesia and S. Africa	10,913	11,120	10,054	17,733	10,097	5,650	
West Africa	27,749	21,194	32,422	44,125	19,147	5,508	
Australia, Iraq, &c.	10,390	12,624	11,990	19,218	15,982	6,106	
Malta and Cyprus	5,121	2,452	2,687	3,989	5,071	3,028	
West Indies	5,938	6,080	4,088	5,295	5,672	5,106	
	368,261	339,748	467,867	416,732	395,725	471,090	
500 lb. bales	294,609	271,798	374,294	333,386	316,580	376,872	

* 400 lb. bales.

The next question is how all this has affected Empire crops. It was of course to be expected that the very low level of American cotton prices during the last two seasons would prove a serious discouragement to the Empire cotton fields, but as will be seen from Table II the actual reduction in the Empire crops has not been very serious except in the case of India, where the reasons are not mainly associated with prices.

The fact is that since the war the Indian crop has developed a curious habit of playing see-saw with the American crop. In 1926, the last year when the American was a bumper crop, the Indian crop was the smallest for five years. In 1927 when the American crop collapsed the Indian made a good recovery. Since then the Indian crop has been dropping steadily and in 1931 it was the smallest since 1920 when, again, to complete the coincidence, the American crop was the largest since before the War. In 1932, with the American crop again a comparative failure the indications are that the Indian crop will be something more like normal, though the figure given in Table II is of course entirely an estimate, for the Government does not publish its first forecast of quantity until December. In passing it should be noted that the figures of the Indian crop in Table II are the Government's estimates which are in 400 lb. bales. As these estimates are nearly always very much on the low side this

Table III.—World's Cotton Consumption. Empire *vs.* Foreign.

Running Bales 000's.

1929-30.	Grand Total.	American.*	Egyptian.	Foreign Sundries.	Indian.	Empire Sundries.	Total Empire.	Per cent. of Grand Total.
U. K. ..	2,465	1,474	301	323	188	179	367	14.9
Continent ..	7,889	4,055	415	1,998	1,375	46	1,421	18.0
Asia ..	7,713	1,427	58	1,705	4,403	120	4,523	58.6
U. S. A. ..	6,052	5,803	137	51	61	—	61	1.0
Others ..	1,082	256	26	740	60	—	60	5.5
	25,201	13,015	937	4,817	6,087	345	6,432	25.5
1930-31.								
U. K. ..	1,964	991	242	334	252	146	398	20.3
Continent ..	6,861	3,242	420	1,936	1,215	46	1,261	18.4
Asia ..	7,407	1,345	96	1,563	4,318	86	4,404	59.5
U. S. A. ..	5,239	5,084	70	42	43	—	43	0.8
Others ..	1,010	239	25	711	35	—	35	3.5
	22,481	10,901	853	4,586	5,863	278	6,141	27.3
1931-32.								
U.K. ..	2,386	1,342	301	374	183	186	369	15.4
Continent ..	6,282	3,344	480	1,645	728	87	815	13.0
Asia ..	7,723	2,636	120	984	3,834	149	3,983	51.6
U. S. A. ..	4,847	4,747	53	26	21	—	21	0.4
Others ..	1,085	250	26	786	23	—	23	2.1
	22,323	12,319	980	3,815	4,789	422	5,211	23.3

Details of the World's Consumption of Empire Cottons, 1931-32 (other than Indian)—Running Bales.

	West Indian.	Iraq.	Sudan.	East African.	West African.	South African.	Australian.	Total.
U. K. ..	15,132	4,484	93,564	24,470	41,241	6,883	62	185,836
Germany ..	3,615	534	157	1,104	51,264	3,415	98	60,187
Switzerland	—	—	542	1,210	1,541	35	—	3,328
Holland ..	—	—	—	2,794	3,077	59	—	5,930
Czecho Slov.	—	—	195	465	9,889	—	—	10,549
Other Europe	551	865	65	312	4,844	—	—	6,637
Japan ..	—	—	—	—	765	—	—	765
India ..	7	601	6,045	128,291	3,961	9,574	—	148,479
	19,305	6,484	100,568	158,646	116,582	19,966	160	421,711

* Excluding linters.

probably justifies retaining the Government figures at their face value in that table, although all the rest of the figures in the table are in 500 lb. bales.

As to the new fields in the Empire it appears from Table II that the total production has suffered very little in recent years, in fact 1931 was probably a record; the reason for this will be found in the details given in the second part of that table (which are in 400 lb. bales). The fact is that the two main Empire crops, the Sudan and East Africa, have recently passed through a period of abnormal vicissitudes. In 1929, the Uganda crop, which is, of course, the great bulk of the East African production, had a very bad year, although the last two years have shown a considerable recovery. In the Sudan again the 1929 crop was far from good, because although the actual figure was little less than in 1928 it ought to have been a great deal more, as the acreage showed a substantial increase. In 1930 things were a great deal worse, for with acreage again increased the crop fell away very badly, and the average yield per acre was the smallest since this field came into operation. In 1931, fortunately, conditions were very much better and with a slightly reduced acreage, due to the measures taken to combat the pests which had caused the damage in the two previous years, the crop was by a long way the largest on record. In other parts of the Empire, as will be seen from the table, the crops of the last year or two have shown a very serious decline, especially in South Africa, West Africa and Australia.

In the West Indies the last three years have shown a substantial recovery from the low point of 1928, for that was largely due to the ravages of pink boll worm, and the steps taken to deal with the pest have proved very effective. It may be mentioned here, however, that the whole position of the Sea Island supply has been materially altered in recent years by the rapid extension of the Sea Island crop in Porto Rico, which has grown from less than 1,000 bales (of 500 lb.) in 1927 to nearly 4,000 bales in 1930. It is of course no secret that the recent development of this new field was mainly due to the operations of an important British firm, which established a ginnery in the Island and had done a great deal to develop the crop with marked success, for the fact must be faced that the Porto Rico crop in 1930 was nearly as much as the whole production of the British West Indies, which was only about 4,500 bales of 500 lb. But the fate of this crop provided a curious illustration of the reactions of political and financial affairs on cotton growing. When the U.S. Government imposed a tax of 7 cents per lb. on long staple cotton the Porto Rico crop of course scored a great advantage because Porto Rico is American and their crop passed into the United States free of the duty. In spite of this the bulk of the crop continued to go to British spinners. When England went off the gold standard both British and American spinners were at a disadvantage in buying the Porto Rico crop, compared with British West Indian cotton owing to the handicap of the rate of exchange, and it is presumably as the result of this change in the position that it is now announced that the Porto Rico ginnery is closing down; which will probably mean the reduction of the crop to a negligible quantity.

Turning now to the question of consumption, Table III summarises the main features of the world's consumption for the last three years, differentiating between the chief cotton spinning areas of the world and the most important varieties, especially Empire growths. The first point is the sharp reduction of the world's total consumption of all kinds of cotton from 1929-30 to 1930-31 as the result of the world depression. In 1931-32 the world's total consumption decreased very slightly, its distribution as already stated showing marked changes, American having gained at the expense of Indian and Foreign Sundries. Egyptian also showed a good recovery, largely as the result of the comparatively low prices, especially of Uppers, during the early part of the season, and still more of the very determined efforts made by the Egyptian Government to dispose of part of their huge stocks to countries which had formerly used mainly American cotton, but were now persuaded by the extremely favourable financial terms offered to use Uppers instead. It may be noted in passing that the relatively low price of Uppers gave place later in the season to a much higher comparative level, and this abnormal consumption is not likely to be maintained in the coming season.

Perhaps the most interesting item in the table is the consumption of Empire Sundries. The figures for 1931-32 show a very substantial increase on 1930-31 and even on 1929-30. Unfortunately, however, these statistics cannot be taken quite at their face value. They are founded on a table published by the Federation which is described as "Specification of part of the cotton returned as Sundries", but as was pointed out in 1931 the information given in this table is far from complete. In the first place it does not cover all the countries concerned. A much more serious difficulty is that it does not distinguish between Empire and other sources in the same area; *e.g.*, under the heading of "West African" Germany was reported to have taken last year 51,264 bales and England 41,241, while various other countries made up the total to 116,582 bales. As will be seen from Table II, however, the whole production of British West Africa in the previous year was less than 20,000 bales. On the other hand France's various possessions in West Africa produced altogether about 50,000 bales of cotton of which France is credited with consuming only 22,171 bales. It is clear therefore that the consumption of West African cotton which we have credited to the Empire cannot all have come from Empire sources.

A similar difficulty arises with regard to West Indian where the total consumption credited to various countries is 19,305 bales against a total production of the British West Indies of about 5,000. This of course may be partly explained by the Porto Rico crop already referred to, but the consumption no doubt also includes a good deal of West Indian cotton which is not Sea Island at all, *e.g.*, Marie Galante cotton from some of the British islands and others of still lower grade from Haiti, which is credited with a crop of about 20,000 bales.

While making allowance for all this the fact remains that the world's consumption of cotton from the Empire's new fields in 1931-32 was apparently the heaviest on record, 422,000 bales against 345,000 bales in 1929-30 which was the previous record. The details of the world's consumption of Empire cotton, which are given in the second part of Table III, are interesting. Of the United Kingdom's consumption more than half is Sudan. Apparently we use more West African than East African which is very unlikely, but on that point the most notable figure is the consumption of East African in India, which has always been fairly heavy but has apparently reached record dimensions during the past season. It will be noted that the South African total is also well above recent production figures even including Rhodesia.

The position with regard to the consumption of Indian cotton is of course much less satisfactory, the world's consumption showing a steady decline for the last three years, but that was inevitable in view of the smaller crops and the relatively high price. One very significant fact, however, emerges from Table III as a whole. The consumption of cotton of all kinds in Asia last season was not only higher than in the previous season but even higher than in 1929-30 which was their previous record year. No other area can show anything like the same improvement. The total consumption in the United Kingdom showed a material improvement on the previous season, which was the lowest on record except 1920, so that the improvement is only comparative. The details again are interesting. We use more American and more Egyptian but also more Foreign Sundries, and the increase there is largely due to the consumption of 134,549 bales of Russian cotton against 53,398 in the previous season and a negligible quantity in previous years.

The discussion of these details may seem to to be of purely statistical interest, although there is a good deal more in it than that. It is evidence of the constant process of substitution which has been characteristic of the cotton world in recent years and which is now going on all the time and in every direction. From the point of view of consumption the whole aspect of the cotton world has changed since the War. In the old days the world's cotton consumption was divided more or less into water-tight compartments. America used practically nothing but American; England used American and a great deal of Egyptian for entirely different trades; the Continent used mostly American with some Egyptian and a little Indian, while the East used very little except their own cotton. But now things are much more complicated and there are no watertight compartments, except perhaps the United States which are still comparatively self-contained. Lancashire to-day uses every kind of cotton that it can get, and rings the changes on them almost daily according to relative prices, *e.g.*, Peruvian (Tanguis) East African and Egyptian Uppers. In the American section in recent years Lancashire has switched about between American, Brazilian, Argentine and now Russian. India is not now content with her own crop and a little American. She uses East African instead of the better grades of American or the lower grades of Egyptian, and last year she bought practically the whole of the Sudan crop of 1930-31; for that crop was so far below normal in quality as well as quantity that it was quite unsuitable for its usual channels of consumption. China of course has its own local crop as well as Indian to play off against American. Japan does the same, with a substantial crop of her own in Korea to help. Even Russia, which used to import large quantities of American cotton, can now replace it very largely by her own growths, but when it suits her she can buy cheap Egyptian and export her own good cotton to England.

Even Sea Island, which used to be most particularly in a class by itself, is no longer free of competition, for Egyptian Sakel has taken away a very large part of the trade which formerly relied on the American Sea Island crop. The market for Sea Island cotton is of course always very limited, and the slight signs of revival which it showed a year or two ago have unfortunately not been maintained, which, however, may be partly attributed to the fact of the rival supplies from Porto Rico. The trouble about Sea Island is the heavy world stocks. There are of course no statistics available of the stocks of Porto Rico cotton, but it may be assumed that they are relatively not smaller than those of the British West Indies.

In all this struggle for the survival of the fittest the cottons from the Empire's new fields are very favourably placed. Sea Island cotton from St. Vincent and St. Kitts is still the very best of the Sea Island supply. Sudan Sakel is equal to all but the very best of the Egyptian Sakel crop, and is now quite a serious rival to it in terms of quantity. The American cotton grown in East Africa compares favourably with the best of the Upland types grown in America even in the Mississippi Delta, while even in India the very marked improvement since the War in the supplies of what are there regarded as long staple cotton, *i.e.*, above $\frac{7}{8}$ of an inch, has enabled India normally to supply her own needs for that class of cotton. Thus the Empire has a finger in every pie, and is therefore in a position to weather the storm of the present depression better than any other single cotton growing country.

STUDIES IN TROPICAL LAND TENURE.

By H. Martin Leake, sc.d.

V. West Africa.—*Continued.*

Nigeria.

Nigeria, like the other West African dependencies, has arisen by a process of gradual development and consolidation. With the cession of Lagos in 1861, a period of penetration succeeded which, as in the Gold Coast, lacked any secure legal basis. On the Niger itself the penetration arose from the activities of a number of competitive trading organizations which, in 1879, were amalgamated to form the United African Company itself to be, in its turn, absorbed, in 1882, in the National African Company. This, in 1884, acquired by purchase the business of the Societé Française de l'Afrique Equatoriale and the Compagnie de Sénégal and thus established a virtual monopoly of the trade of the Niger and Benue regions. With the grant of a Charter in 1886, the name was changed to the Royal Niger Chartered Ltd., and under its Charter it undertook the dual function of a trading and administrative body.

Meanwhile the activities of other nations in the West African sphere were gradually compelling the attention of the home Government to a more definite declaration of the position. Early in 1885 the Berlin Conference secured the application to the Congo and Niger of the free navigation articles of the final act of the Congress of Vienna in 1815, a settlement which is reflected in the trading terms of the Charter granted to the Royal Niger Company. But the Berlin Conference also influenced the future British policy. The early cession of Lagos was the result of King Docemo's failure to surpress the traffic in slaves and, from that centre, penetration took place particularly to the east, the effectiveness of which was recognised in the Anglo-German Agreement of 1885 which followed the Berlin Conference. This Agreement delimited the eastern boundary of the British sphere of influence and its signature was followed by the formal declaration of a Protectorate over the territory under the name of the Oil Rivers Protectorate. This territory included both banks of the Niger from the coast to its confluence with the Benue and both banks of the Benue as far as Ibi. To this territory was added the hinterland in 1893, the whole area receiving the name of the Niger Coast Protectorate. In 1900 a further change of name was made to that of the Protectorate of Southern Nigeria and in 1906 this territory was amalgamated with Lagos to form the Colony and Protectorate of Southern Nigeria.

To the north and west, on which sides contact was with the French, the delimitation was delayed and it was not until 1890 that an Anglo-French settlement was reached under which the kingdom of Sokoto was placed within the British sphere. The exact limits of that kingdom were, however, indefinite, and only in 1898 was a delimitation undertaken. Meanwhile the Royal Niger Company had not remained inactive. Under its Charter, it proceeded to bring extensive areas of the hinterland under British protection by concluding a large number of treaties with native chiefs which conformed to one or other of ten standard forms. In these treaties appear the first indications of the future land policy. The major obligations incurred under these treaties are; non-interference with native laws, the settlement of native disputes and the payment of a reasonable sum for any portion of land required (1). The chiefs, on their part, agreed to enter into no commitments except with the assent of the Company. When, however, the validity of some of these treaties with chiefs (Emirs) on the northern border was questioned by the French, an international aspect arose and a revocation of the Charter was decided on by the British Government. That revocation was followed, in 1900, by the proclamation of a Protectorate over the whole area. Thereafter a series of administrative changes followed which led, in 1914, to a fusion of the whole territory under one administration with the title of Nigeria, divided into the Colony and Protectorate of Nigeria, the latter being sub-divided into the Northern (the old Protectorate of Northern Nigeria and Southern Provinces). Thus is repeated the triple division found in the Gold Coast. To these administrative changes, as well as to its union prior to 1886 with the Gold Coast, is due a certain complexity in tracing out the history of the land policy in the dependency.

Associated with this triple division arising from a diversity of origin based on history, is a climatic difference which is, again, comparable to that found in the Gold Coast. The coastal tracts which form the Colony and Protectorate of Southern Nigeria, constitute a region which is typically forestal. To the north the forest passes into the scrub and open country which is characteristic of Northern Nigeria with its continental climate and lower rainfall. Ethnologically, too, the contrast between north and south is even more marked than in the Gold Coast, for the Northern Territories came under the full influence of the Moslem penetration of the middle ages. Though the hegemony then established broke down later, there have remained a number of powerful Emirates in which Moslem law and custom prevail.

The Colony and Protectorate of Southern Nigeria.

The comparison with the Gold Coast extends still further for, on the cession of Lagos, there is to be found that same neglect of native custom and imposition of English law in matters concerning land. Till 1886 Lagos was administered from the Gold Coast and the same principles

governed the administration of land questions in both territories; English law in its entirety was applied and land came to be regarded, both in Lagos and its neighbourhood, as a personal asset. There is no settled and guiding policy here, but a gradual evolution, based on legal decisions which received administrative countenance in 1888 when a General Registry Ordinance (Ord. 9 of 1888) led to the establishment of a Registry Office in Lagos. Thus, to a large extent, passed the indigenous land system, a typical communal system under which the tribal chief administered the land as trustee for the community, distributing it among families as the land holding unit but with the responsibility of trustee without power to alienate. The essential principles of the native system are given in a judgment of the High Court, Lagos, in 1892 (2). Till 1891 no clear definition of the land question had been made but in that year the discussion which raged in full force in the Gold Coast, was extended to include all the West African Colonies. As a reflex of that discussion, in 1897, the same year as the land ordinance of the Gold Coast was still-born, *Gazette* Notification (Lagos) No. 242, notified that "no document hereafter made purporting to convey any right over or interest in land save and except the right to occupy agricultural land for the purpose of native husbandry or the right to occupy building land for the erection of a native house will be recognized in any way by Government unless it bear the signature of the Governor. Grants and concessions already made without such consent will be recognized only to such extent and on such conditions as may be hereafter determined, but the grantees of rights in respect of which there is reasonable prospect of efficient and continuous work being done within a reasonable time will receive all due consideration." A more detailed explanation of the limitation contemplated is given in a further *Gazette* Notification (No. 243 of 1897). Both these notifications are reproduced in Sir P. Giruard's memorandum of 1909 to the Northern Nigeria Lands Committee (3).

The Protectorate of Southern Nigeria took shape as the modern outlook was gaining force and the first action to be taken after its constitution was the issue of the Dealings with Natives Proclamation (Proc. 1 of 1900) which was extended by the Lands Acquisition Proclamation of 1903 (Proc. 1 of 1903). Under these the written consent of the Governor was required to the acquisition of any interest in land by an alien; but, by the Land Registry Proclamation (Proc. 8 of 1900) provision was made for the registration of titles to land Thus, while recognizing the application of English law as far as it already had gained acceptance, these Proclamations put a check on the further application of the principles of that law and, by placing the acquisition of land by aliens under the control of the Governor, they rendered unnecessary the complex procedure of the Gold Coast Consessions Ordinance. But, as in the Gold Coast, the conservation of the forests was also exercising the mind of Government and, in 1901, a Forestry Proclamation (Proc. 28 of 1901) was issued which placed full powers for regulating native wastes and forest reserves in the hands of the High Commissioner, while an Ordinance of similar tenor was passed for the Colony of Lagos (Ord. 14 of 1902). In the latter case, however, the Ordinance remained very much of a dead letter since its enforcement in the hinterland was made contingent on the assent of the Native Councils.

The future development of the land policy in Southern Nigeria is contingent on Northern Nigerian policy for, after the fusion of the two territories in 1914 under one administration, the trend of that policy is largely conditioned by the experience gained further north and consists of the adoption, as far as circumstances permit, of administration through the native authorities which were in process of establishment.

Northern Nigeria to 1914.

The land legislation of Northern Nigeria offers a study of particular interest for two reasons. On the one hand it illustrates the direct application of devoluted control from the commencement of British occupation, a fact due to the foresight of Sir Frederick (now Lord) Lugard; on the other, over a large portion of the territory the indigenous system of Hausa tenure had already been superseded by an alien Moslem system introduced by the conquering Fulani, a race supposed to be descended from the Berbers. But this alien system had never been adopted in its entirety; below a considerable residuum of Hausa custom remained, a custom having the usual attributes of communal land with family right of occupancy. In the absence of any pressure on the land, due to the unsettled state of the country and the prevalence of slave raiding, these customs remained ill-defined while cultivation was largely of the shifting type. Over this primitive system, where control was sufficiently established, was superimposed the alien Fulani system based on Moslem custom and the Koranic law. Land tenure, under this system, became associated with the collection of revenue and, as in India under the Moslem dynasty, the land is apportioned to tax collectors with the tax fixed at one tenth of the produce, the Koranic tax or 'ushur'. If, in India, the central authority was decadent at the time of the British occupation, in Northern Nigeria it had ceased to exist and the country was distributed among a number of Emirs each of whom exercised uncontrolled authority within his Emirate. When to this, is added a state of open hostility between neighbouring Emirates and active slave-raiding on the bordering pagan tribes, the scene is set for intensification of taxation beyond the Koranic limits and, in fact, farming out the revenue, the sign of decadence, developed.

This briefly describes the conditions at the time when a British Protectorate was declared over the whole territory. But the declaration of itself

did not give control of the country and the active opposition of the Emirs was only finally overcome in 1906 by measures which amounted to conquest. The details of this conquest are not germane to the present subject and are to be found in brief outline described by Lucas (4); what has a bearing is that Lugard, the first High Commissioner of Northern Nigeria, foresaw the need for an early definition of the attitude to be adopted on the land question, that, to quote his own words, "whatever the intention of the conqueror in regard to land, it must be declared as soon as possible after the conquest is completed" (5). Adopting this policy, he issued to each Emir on appointment or reinstatement a letter, which was read publicly, stating clearly that whatever rights in land had belonged to the Fulani would now inure to Government, the exact definition of these rights being left for later determination.

Before the enquiry which must precede such definition, could be undertaken, certain points demanded immediate action. There was the ever pressing problem of alienation and there was the question of the position of the lands acquired by the Royal Niger Company. The former point was early met by Proclamation (Proc. 8 of 1900 amended by Proc. 11 of 1906) under which it was provided that no person other than a native of the Protectorate should directly or indirectly acquire any interest in land from a native without the written consent of the High Commissioner; the latter point by the Crown Lands Proclamation (Proc. 16 of 1902), confirming an agreement with the Company and under which Government secured the absolute title to certain named lands. Of wider scope than this last Proclamation is a further Proclamation (Lands Proc. (Amendment) Proc. 13 of 1902) which permitted the High Commissioner to declare as Public Lands both lands not in actual occupation and lands being the property of any conquered race. This early policy was rounded off by a Land Registration Proclamation (Proc. 10 of 1901) which provided a system by which native holders could secure a title to their land.

The final settlement for which the above Proclamations merely paved the way, was delayed, the complexity in large measure arising from the fact that, under the prevailing Moslem system, taxation and land tenure are intimately bound together. It is not possible to enter into the lengthy discussion which arose on this subject of taxation as it bears on the land. The main features of the established system, which bears many striking similarities to that of Northern India, has been discussed in a memorandum from the pen of Lord Lugard (6) while the theoretical aspects are discussed in his Dual Mandate. The practical issue, including the underlying question of ownership, was referred by the Secretary of State to the Northern Nigeria Lands Committee which reported in 1908 (7).

In 1910 the conclusions reached by the Committee were translated into practice in the Land and Native Rights Proclamation, the Statute Laws Revision Proclamation (Proc. 9 of 1910) under which all lands other than Crown Lands as already defined by Proclamation in 1902 are declared to be Native Lands and are to be under the control and at the disposition of the Governor, to be administered for the common benefit of the natives and with due regard to native law and custom. The rights are limited to rights of occupancy and, except for mining rights, rent is to be charged with a reserved power of revision at least every seven years. The occupier, while having exclusive rights as against all but the Governor, may not sell, mortgage or transfer without the Governor's consent. Devolution of rights on death is to be in accord with native custom or, in the case of an alien, with the law of his domicile.

The Proclamation aimed, too, at solving the question of the method of assessing what is now called the rental, and the same principle of assessment was adopted as that which had been introduced by the Land Revenue Proclamation (Proc. 4 of 1904) and the Native Revenue Proclamation (Proc. 2 of 1906). The basic principle is the capacity of the land to raise crops or carry stock; it is the principle underlying the Indian settlement and the difficulties inherent in such an assessment are obvious. In the absence of any detailed survey and adequate staff, the unit of assessment adopted was the village, and the actual division among the individual members was left to the discretion of the head-man. It is noteworthy, too, that the Proclamation rendered other unauthorised taxes illegal.

United Nigeria From 1914.

The principles of land legislation had already been laid down by the time the territories were fused into one Administration. Subsequent legislation took the form, firstly, of dotting the i's of that policy and, secondly, of the extension as far as possible of the policy adopted for Northern Nigeria to the whole of the area. It is a policy of annual assessment of land revenue based on productive capacity under the average standard of cultivation; the assessment being by communities (villages). The system is formularized by the Native Revenue Ordinance (Ord. 1 of 1917) which embraces, not only the above assessments on land, but assessments on stock, to cover the case of pastoral tribes, and on profits on trade; the tax, thus, partaking of the nature of an income tax rather than of rent. The Ordinance, as passed, applied only to the Northern Provinces but the Governor was empowered to extend its application to the whole, or any part, of the Southern Provinces, a permission which did not remain unused. In 1928 an amending Ordinance (Ord. 17 of 1927) was passed which applied to the whole Protectorate, excluding the Colony but including the British Cameroons.

On the question of tenure, for the historical reasons sufficiently described above, the adoption of uniformity has not been carried to the same degree. The position of Crown Lands, both in the Colony and Protectorate, has been stabilized

by the Crown Lands Ordinance (Ord. 7 of 1918), under which the Governor is empowered to sell only with the sanction of the Secretary of State, but may lease on rental. The distinction between the old Northern and Southern Protectorates is carried forward into the Land and Native rights Ordinance (Ord. 1 of 1916) with its frequent subsequent amendments, for it applies only to the Northern Provinces with the associated part of the British Cameroons. To this Ordinance is appended a preamble defining its triple purport of assuring existing customary rights of natives to use and enjoy land, of preserving as far as possible existing native customs as to the use of land and of defining the obligations of Government. The whole of the lands are declared Native Lands and are to be administered by Government for the benefit of the natives. The single form of title is an inalienable one of Occupancy for a definite, or indefinite, period and for which a revisable rental is charged. Titles may be granted to natives or non-natives but, in the case of the latter, no single right may exceed 1,200 acres for agricultural, or 12,500 acres for grazing, purposes, while any native resident on such areas remain subject to native control. Devolution on death of a native occupier is to be adjusted by native custom, subject only to any subdivision requiring the consent of the Governor.

The position of aliens in the Southern Provinces is defined by the Native Land Acquisition Ordinance (Ord. 32 of 1917) which reasserts the necessity of the written consent of the Governor to such transactions.

In all this land legislation a reservation of mineral rights is made and the granting of these rights is covered by the provisions of the Minerals Ordinance (Ord. 10 of 1916) which has a universal application. In the matter of forestry the law has been consolidated by the Forestry Ordinance (Ord. 12 of 1916) which empowers the Governor to create reserves from land at the disposal of Government or native lands, land acquired by agreement from natives or native communities and land on which, according to the advice of the Director of Forests, the destruction of the forest is diminishing or likely to diminish the water supply or injure the agricultural conditions of neighbouring lands or imperilling the continuous supply of forest produce to the contiguous village communities.

In much of this legislation there is to be traced a similarity to the later legislation in the Gold Coast, the cause of which must be traced to the tendency to study the whole land problem of West Africa as a single entity, a tendency which is exemplified by the appointment of the West African Lands Committee to which reference has already been made.

The tendency of all this legislation is in the direction of production based on a peasantry; the plantation system of cultivation of large areas by alien agency, if not excluded, is not actually encouraged. As elsewhere, the problem arises as to how organization to supply an export market is to be provided. The major agricultural exports of Nigeria are the products of the oil palm and cotton; the former is mainly the product of the wild or semi-wild growth and, in this respect, is hardly to be considered an agricultural product in the strict sense. The latter is a truly agricultural product, the production of which, moreover, was directly stimulated by the movement, started early in the century, to find fields for cotton growing within the Empire. Among the various territories to which attention was directed, Nigeria was one of the chief, and the history of that movement within the territory is not without interest here, for cotton, more than any other crop, illustrates the need for organization in production for export. It is, in the first place, an annual, grown from seed and cross-fertilization is sufficiently common to demand an organized seed supply; for the major part, also, it is an exotic and liable to disease demanding protective measures (8), and, finally, price is dependent on uniformity so that marketing must be organized in a country where a low quality indigenous cotton is grown.

The earliest effort at the stimulation of cotton growing was made in 1902 when the British Cotton Growing Association was founded to foster the growth of cotton within the Empire. In that year an arrangement was entered into under which all the work of development was entrusted to the Association. In 1904 a new arrangement was made by which Lagos and Southern Nigeria contributed £5,000 per annum while the Association undertook to provide staff, to spend £30,000 in the course of three years on each plantation established and to organize buying.

In these early days the plantation system still held the field as affording the readiest means of development and expert opinion was in favour of the ploughing and fertilizing being carried out for the native, leaving the latter only weeding and picking (9).

In 1907 a further arrangement was made. Southern Nigeria (now combined with Lagos) contributed £5,000 and Northern Nigeria £1,000, while the Association agreed to spend a like amount in experimental and instructional work. In 1910 yet a further arrangement was made; while Government undertook to maintain scientific and instructional work with a contribution of £10,000 from the Imperial Government, the Association agreed to raise a further £150,000 capital, to erect and maintain therewith buying and ginning centres, to provide a seed supply to be distributed by Government and to conduct travelling and missionary work (10). In these later years, largely owing to difficulties of labour, the plantation system had been given up.

With the development of the Agricultural Departments, especially after the War, the transfer of functions from the Association to Government advanced a further stage with the result that the latter body now undertakes merely the function of agent of Government for ginning and buying. To Government, therefore, as has been seen to be the case elsewhere, has fallen the duty of

organizing the production of cotton, as of other agricultural produce, so that, from a multiplicity of small units, an exportable product may be forthcoming.

The first steps in this direction were taken in 1916 by the passage of an Ordinance for the prevention of introduction and spread of pests and for the control of cotton growing and preparation of cotton (Ord. 55 of 1916). It was a permissive Ordinance and conveyed wide powers of regulation for, among other matters, regulations may be made for generally maintaining and improving the quality of cotton. Power to appoint Inspectors is also given. Regulations were issued in 1917 under this Ordinance regulating imports of cotton seed, for declaring areas in which only American cotton might be grown and for the eradication and burning of all cotton and Hibiscus plants by notified dates. The power to deal with all crops was exercised in 1918 when Regulation 59 was issued which enforced the cutting down of palms attacked by bud-rot and prohibited cabbage tapping. A revised Ordinance was passed in 1926 (Ord. 4 of 1926), of much the same tenor and, under it, a number of Regulations have been issued, particularly Regulation 26 of 1926 which, among a very comprehensive set of rules, forbids the sale and distribution of cotton seed for sowing without the sanction of the Director of Agriculture. Palm oil, palm kernels and cacao are dealt with under Regulation 20 of 1928 which lays down a comprehensive scheme of grading and inspection under Government agency. As has been seen in other territories, the pressure of the world's markets, with their insistence of a graded product, is driving Government more and more to undertake the responsibility of supervising production in all its stages.

Sierra Leone.

The first contact of the British with Sierra Leone occurred in 1787 when a grant of land was obtained by a group of philanthropists from King Naimbana for the settlement of liberated slaves. In 1788 King Naimbana took an oath of allegiance to the King of England and indicated therein that the grant, which referred to an area of some 20 square miles including the site of Freetown, was made to the Crown for the purpose of establishing a free community of British subjects. In 1791 this group took the form of a Trading Company, the Sierra Leone Company, with a Charter but the ceded land remained vested in the Crown. In 1808 the Crown resumed the area from the Company and from this date Sierra Leone became the West African base for putting a stop to the slave trade and for penetration into the interior by trade missions. Thereafter followed a series of cessions from the natives and, towards the end of the nineteenth century, the boundary questions which these expansions of territory raised, were determined by an Anglo-French convention.

The territory forms a Crown Colony and is divided into the Colony proper and the Protectorate, the division between the two being defined in the Protectorate Ordinance (Ord. 33 of 1901). Of the Colony proper little need be said. The area is small and, as in the other West African Colonies, English law has been adopted and private ownership of land is recognized. The Protectorate is broadly divided into two ; a coastal belt, afforested and a home of the oil palm, the oil and kernels of which form the major exportable product, and a dryer hinterland. There is in the Protectorate no pressure on the land while the absence of minerals and unattractiveness from the agricultural aspect have raised no demand for land for development by aliens. Any such demand is met by the Concessions Ordinance (Ord. 8 of 1902). The Protectorate was included in the area in which the British Cotton Growing Association carried on the experimental work described above but the small success achieved led to relaxation of the effort to establish cotton growing. Under these circumstances a free field remained for the development of a land policy based on the indigenous system. This system is typically tribal and all land is vested in tribal authority (Ord. 16 of 1907). Any rights in land, except such as are governed by the Concessions Ordinance, are only obtainable under this Ordinance which sums up Part III of the Protectorate Native Law Ordinance (Ord. 16 of 1905), and is directed to solve the problem of native infiltration. Land for public purposes is acquired under the Land Clauses Ordinance (Ord. 1 of 1872). The administration of land is conducted by tribal authority, the elementary nature of the tenure being indicated by Part II of the Protectorate Native Law Ordinance already mentioned. Taxation is based on houses, and rent, if it can be called such, is referred to in the Ordinance as 'customary present'. The main function of the Ordinance is to regularize the employment of labour required by Government on public works and by the chiefs. Thus, "no chief shall cultivate or order to be cultivated for his own benefit a larger area than can be cultivated by his own labour or by the people aforesaid without preventing such people from having sufficient time to cultivate their own land". By the Protectorate Courts Jurisdiction Ordinance (Ord. 6 of 1903) the Court of the Native Chief decides all cases of land dispute exclusive of those between Paramount Chiefs. Forestry is dealt with under the Forestry Ordinance (Ord. 8 of 1912) which permits the delimitation of Reserves on Crown Lands and on tribal land at the request of the tribal authority. Survey has not been an urgent matter and the Survey Ordinance (Ord. 20 of 1927) renders permissible a survey at the request of owner or occupier.

The system of tenure is, thus, a very elementary system of peasant proprietorship and recourse is to the same methods of official regulation of the exportable produce as has been noted in the other West African Colonies. The earliest attempt

at regulation appears to have contemplated control through external agency for, in 1913, the Palm Oil Ordinance (Ord. 7 of 1913) was passed which empowered the Governor, with the consent of the tribal authority, to grant exclusive renewable rights, not exceeding 21 years in the first instance, for the erection of power driven mills, the controlled area being not greater than a circle with a ten mile radius. In 1917 was passed the Native Produce Ordinance (Ord. 8 of 1917), a permissive Ordinance followed, in 1924, by a Native Standard and Grading Ordinance (Ord. 30 of 1924) also of a permissive tenor and consolidated in the Native Produce Ordinance (Ord. 16 of 1928). The control is exercised through a system of licensing dealers and of inspection of produce.

The Gambia.

As a source of natural produce the Gambia offers little scope. Of limited area, it exhibits the linked features of an unfavourable climate and a sparse population; it has none of the wealth of tropical rains growth characteristic of the coastal tracts of the Colonies already described. Historically its development has followed closely that of the remaining West African Colonies. British influence was originally limited to a coastal station controlled by the Royal African Company but taken over by the Crown early in the nineteenth century. In 1894 the Protectorate system was introduced, the Colony proper being limited to a small coastal tract of some 69 square miles.

These are conditions under which any question of land rights assumes small importance and the dominating problem, if this is not too emphatic an expression, is one of native infiltration by a floating population from neighbouring colonies comparable to that of the Irish harvesters (11). It is not surprising, therefore, that much remains vague on the subject of land and even the exact relation of the Crown to land is not clear. Thus the Protectorate Ordinance (Ord. 30 of 1913), which governs the administration of land, makes applicable all native laws and customs which are not repugnant to natural justice nor incompatible with the principles of the Law of England, from which it would appear that English Law is prevalent. In practice, however, the land administration follows closely that already described in other Protectorates and, under the Protectorate Ordinance, land cases come before the Native Tribunals and are decided by native custom. Such differences as exist are minor and offer no point of outstanding interest.

Control of produce, to the small extent that it has been developed, exhibits the same tendency as elsewhere to become the function of the State and the first step was taken by the permissive Plant Protection Ordinance (Ord. 18 of 1924) under which powers to control the importation of plants and to declare diseases were conferred.

References.

(1) Cd. 9372; *Accts. and Papers*, 1899, 63, p. 417; where the forms of treaties and a list of chiefs are given in full.
(2) Cd. 5103, App. 4; *Accts. and Papers*, 1910, 44, p. 305.
(3) Cd. 5103, App. 4; *Accts. and Papers*, 1910, 44, p. 305.
(4) *Historical Geography of the British Colonies*, Vol. 3, West Africa; Sir Charles P. Lucas, 1913.
(5) *The Dual Mandate*, p. 289; Sir F. D. Lugard, 1922.
(6) Cd. 3309; *Accts. and Papers*, 1907, 54, p. 473.
(7) Cd. 5102; *Accts. and Papers*, 1910, 44, p. 271.
(8) Pomeroy, A. W. J., *Empire Cotton Growing Rev.* 1926, 3, p. 36.
(9) Ann. Rep. S. Nigeria, 1903; Cd. 2238, *Accts. and Papers*, 1905, 52, p. 297.
(10) Cd. 5215; *Accts. and Papers*, 1910, 66, p. 65.
(11) Ann. Rep. for 1927.

MYCOLOGICAL NOTE.

Methods of handling dangerous material (Specimens and Cultures) in Mycological Laboratories.

1. *Transmission of specimens of plant diseases from one country to another country.*

(*a*) Fresh specimens of a plant carrying a dangerous disease should not be transmitted from a mycological laboratory in one country to a mycological laboratory in another country where that plant or other susceptible plants are under cultivation, but are free from the disease; if such specimens are received, they should be burnt without delay together with the packing material, or be rendered innocuous in some other effective way.

(*b*) In the event of such specimen being transmitted as an 'exsiccatum,' it should be poisoned before despatch (*e.g.*, by painting it with or dipping it into a one per cent. solution of mercuric chloride in strong alcohol) and be marked 'poisoned.'

2. *Cultures of plant pathogenic organisms.*

When cultures of such organisms (in plates, tubes, etc.) are being discarded, they should be killed, either by flooding them with a mixture of strong alcohol and formaldehyde solution, or a 1 per cent. solution of mercuric chloride in strong alcohol, and be allowed to lie in contact with the poison for several hours, *or*, if more convenient, by heating in the autoclave under pressure or in a steamer at or very near to 100° C., for a half-hour at least.

3. *General treatment of specimens of dangerous diseases.*

Fresh specimens of plant material infected (or suspected to be infected) by a dangerous disease, which have been collected in a country and taken to a mycological laboratory there, should, after portions have been selected for preserving or culturing, be destroyed as soon as possible by fire in an incinerator which ought to be part of the equipment of all mycological laboratories.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Sugar-cane Research at Coimbatore.

The successful crossing of the sugar-cane with *Sorghum* or *jowar* at the Imperial Sugar-cane Breeding Station at Coimbatore, in South India, by Mr. T. S. Venkatraman, the Government Sugar Expert, is regarded as one of the greatest discoveries in the agricultural world during the past year. It has been demonstrated by this experiment that sugar-cane can be ripened in 6 months instead of 10 or 12 months. This achievement has been very highly complimented by sugar-cane technologists all over the world, as it is expected to revolutionize the sugar-cane industry in India. The work at the Coimbatore Sugar-cane Breeding Station is attracting increasing attention from the outside world, and it is recognised to be in the forefront in the technique of cane-breeding and in root studies. The *Sorghum* hybrids are now being widely tested in various parts of the country, and this new line of work will be carried on at Coimbatore on an extensive scale in the future. The new canes produced at the Coimbatore station have been steadily spreading in the main sugar-cane provinces of India, to the advantage of both the grower and the manufacturer. The cultivation of these canes has resulted in increased production of white sugar from Indian factories. Last year, such production was 119,859 tons, against 52,990 tons five years ago.

One rather important development within recent times is the spread of Coimbatore seedlings of medium thickness. In spite of their lesser girth, they have in certain cases given higher yields than the usual thick types. Perhaps the chief advantage of these medium canes is that they need comparatively less attention, less water and less manure. A variety called Co. 213 has been recently grown in Madras Presidency without irrigation, and what is more, without the expensive operation of wrapping and elaborate propping with bamboos that the canes now under cultivation need.—(*J. Soc. Chem. Indus.*, Vol. LI, No. 42, 1932, p. 865.)

* * *

Mayaguez Sugar-Cane Varieties resistant to Mosaic.

R. L. Davis.

Mayaguez seedlings (crosses between POJ 2725 and SC 12/4) have given good results as plant cane on various Puerto Rican plantations. The more promising of these seedlings at present appear to be Mayaguez 28, 63 and 42, in the order listed. Mayaguez 28, 49 and 7 are recommended for either upland or non-irrigated lowland trials and Mayaguez 28, 3, 42 and 63 for irrigated lowland. Of all these varieties, Mayaguez 28 appears to have the widest range of adaptability, having given satisfactory results both on sandy alluvial lowland and on dry hillsides.

In certain trials as *gran cultura* plant cane Mayaguez 63 at 17 months yielded 92.8 tons of cane with 12.9 per cent. sucrose, corresponding to sugar yield of 11.52 tons per acre, which was 4.5 tons more than was obtained from BH 10 (12) on adjoining plots. This variety ripens late, but appears to be drought resistant and probably will do well on either irrigated or unirrigated lowlands. Like Mayaguez 28 and 49, it is resistant to mosaic disease. The stalks are very thick and non-cracking.—(*Inter. Sugar Journal*, Vol. XXXIV, No. 407, pp. 434-35.)

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The Gyrotiller in Puerto Rico.—*A. F. Bell.**

This article contains observations by a member of the Australian delegation to the congress of the International Society of Sugar-Cane Technologists, held in Puerto Rico in March, 1932. Particular attention is paid to the work of the Fowler gyrotiller at Central Aguirre, on whose plantations one of these machines had been operating for eight months at the time of the author's visit. Excluding interest and depreciation, the cost of preparing cane land for planting by the gyrotiller averaged $2.25 per acre. The machine ploughs a strip 10 feet wide and pulverizes the ground to a depth of about 22 ins. It is driven by a 150 H.P. Diesel engine. In operations covering a total of 176.65 acres, the area prepared per working day was 0.746 acre and the fuel consumption per acre was 5.37 gallons. According to figures supplied by the cost accounting department of Central Aguirre, it appears that land preparation by the gyrotiller is much less expensive than the use of steam ploughs, with the subsequent operations of harrowing, cross-harrowing, ridging, &c.—(*Inter. Sugar Journal*, Vol. XXXIV, No. 407, p. 433.)

REVIEW.

ROTHAMSTED CONFERENCES, XIII.

"The Technique of Field Experiments". *Rothamsted Experimental Station*, pp. 64, price 1s. 6d.

This publication contains the papers submitted to a Conference held in May, 1931, at Rothamsted on this increasingly important subject. Many of these papers traverse ground which is covered elsewhere, but in a subject like this, which for many workers presents peculiar difficulties, it is often helpful to have the matter presented by more than one authority. Perhaps Professor Stapledon's account of the technique of Grassland Experiments which has been worked out at Aberystwith, strikes the most original note with its account of tethered sheep, but all the papers are worth reading, and this little book might well form part of the library of all agricultural students.

R. C. W.

* *Australian Sugar Journal*, 1932, Vol. XXIV, No. 3, pp. 127-28.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Rubber Research in Malaya.

The report on the work of the Rubber Research Institute of Malaya during 1931 deals with the fifth year of the Institute's existence. A general increase in advisory work is noted, particularly in relation to improvement in estate factory practice in order to reduce the cost of production. On the other hand, in the soils division, there has been a diminution of this work except in relation to cultivation and cover crops. As the price of rubber is not likely to be stabilized at a high figure in relation to the price of fertilizers, manuring for rejuvenation seems likely to recede into the background. It has been found that the soil round the rubber tree needs the protection and assistance of a crop of vegetation, so that the modern method of cultivation aims at encouraging weeds under control. A phase of the chemical work which is of immediate industrial importance is that on variability in rubber samples. Not only is there variation, in respect of vulcanization properties, in the products of different estates, but there is also an appreciable variation on the same estate over an interval of time. The problem of conferring uniformity is one for which the solution will probably be found as a result of free exchange of information between growers and users, and of co-operative laboratory tests and large scale trials. On the whole, crepe rubber is less variable than sheet, but on most estates the manufacture of sheet rubber is favoured because it is simpler to control and requires less expensive machinery. The attainment of uniformity is not necessarily associated with heavily increased charges: "given suitable plant, there is no reason why first quality sheet should cost more than 0.25 per cent. per lb. to manufacture in a correctly designed factory handling 5,000 lb. per day, and our results tend to show that where this is attempted by centralising manufacture, the product automatically assumes a degree of uniformity previously unattainable". —(*Chem & Ind.* Vol. LI, 1932, No. 43, p. 867.)

* * *

'Tea Yellows' in Nyasaland.

A communication from the Department of Agriculture of the Nyasaland Protectorate (Bulletin No. 3, new series) records a successful piece of work on the etiology and control of the 'yellows' disease of the tea bush, which has troubled planters in Nyasaland for many years. This work, done by Dr. H. H. Storey, of the Agricultural Research Station, Amani, Tanganyika, and Mr. H. Leach, mycologist to the Nyasaland Department of Agriculture, leaves little doubt that 'tea yellows' is a deficiency disease due to lack of sulphur in the soil and in the plant. An experiment, started in 1927, showed that the application of ammonium sulphate was very effective in restoring the health of severely diseased bushes, and this was followed up by a series of field tests with fertilizers containing sulphur and not containing sulphur, which showed that both prevention and cure are effected by the sulphate part of the fertilisers. Treatment with ground sulphur was also found beneficial. These results were corroborated by growing tea seedlings with their roots immersed in distilled water containing all the essential plant foods, and in solutions from which one of these plant foods was absent. The seedlings grown in the solution without sulphur developed the exact symptoms of 'yellows' disease even down to the scorching of the young leaves. Chemical analysis of leaves from diseased bushes showed a deficiency in sulphur, and mycological investigation indicated that the fungus *Rhizoctonia bataticola*, which is found on the roots of diseased plants, is not the causative agent, but invades the plant after its health has been sapped by the disease. The control measure now recommended is to apply ammonium sulphate or potassium sulphate in a minimum dressing of 1 oz. per old plant or ½ oz. per new plant, or sulphur at the rate of ¼ oz. or ⅓ oz., respectively. The use of kraal manure, which is rich in combined sulphur, is also advocated.—(*Nature*, Vol. CXXX, 1932, No. 3287, p. 668.)

* * *

Tornesit (*chlorinated rubber*).

Tornesit is a chlorinated rubber which should find application as a rust preventive. It is a white powder, insoluble in water, benzine, and petroleum, and is stable up to 150°C., above which temperature it turns brown. This material is not acted upon even by hydrofluoric acid, concentrated nitric and hydrochloric acids, sulphuric acid, or 50 per cent. sodium hydroxide; it is not attacked by weak solutions of hypochlorite or potassium chromate, or by gases, such as oxygen, chlorine, and sulphur dioxide. Its great stability against weathering and resistance to mechanical effects, as well as the unusual hardness of its films and the fact that it is noncombustible, indicate Tornesit as a suitable base for pigments, lacquers, and varnishes for application on metal, wood, concrete, or stone. Tornesit is produced by the Herold, A.—G., Hamburg. The application of Tornesit as insulation material for all products manufactured by the pipe industry is protected by the Mannesmannrohren-Werke, Dusseldorf. Tornesit should also be useful in the manufacture of plastic materials, foils, filaments, artificial leather, floor covering and the like.—(*J. Indus. Engin. Chem.*, News Edition, Vol. X, No. 16, 20th Aug., 1932, p. 209.)

* * *

Plant for Citrus By-Products.

A plant for the recovery of pectin from citrus has been built at Messina in Italy. The dry, pulverised product obtained has a content of pure agglutinating material varying from 60 to 90 per cent. It is used to gelatinize vegetable juices in conjunction with certain amounts of sugar and organic acids; to give the proper density to marmalades; and for emulsifying oils.—(*Ind. & Engin. Chem.*, News Edit., Vol. X, 1932, No. 22, p. 280.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
24th Nov. ..	5	9	10	6
1st Dec. ..	5	4½	10	1½
8th Dec. ..	5	5¼	10	3
15th Dec. ..	5	0¾	9	10½
22nd Dec. ..	5	0	9	9
29th Dec. ..	5	0	9	9
6th Jan. ..	5	0¾	9	9¾
12th Jan. ..	5	0	9	9
(14*th Jan.*, 1932) ..	7	0¾	10	9

The general feeling of uncertainty attaching to World political and economic affairs has weighed heavily on the sugar market, resulting in successive declines in values, both in America and in the United Kingdom. *C. Czarnikow Ltd.* point out that another contributory cause to the fall in prices has been the inability of the United Kingdom to assimilate the heavy supplies of Dominion and Colonial sugars which has been accompanied by increased receipt of Foreign Raws and larger deliveries of the domestic beet product. The present embarrassing supply appears, however, to be purely seasonal and a recovery may, therefore, be looked for.

* * *

COCOA.—The cocoa market generally continues to be very dull and is still influenced by political conditions. The ruling prices in London are :—Superior Bahia at 28*s.* 6*d.* cost and freight, Epoca Arriba at 47*s.* 6*d.*, Navidad at 50*s.* 0*d.*, whilst Good Fermented Accra at 26*s.* 0*d.* to 25*s.* 9*d.* *ex* quay Liverpool and 26*s.* 6*d.* *ex* wharf London. In Trinidad $5.90 per fanega is now being paid for Plantation cocoa.—(*By courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

* * *

TEA.—According to the *Times, Trading and Engineering Supplement*, averages on the 24th December, included Ceylon 19.08*d.* per lb., Indian 7.26*d.*, Java 6.05*d.*, Darjeeling 11.98*d.* Prices of many kinds have declined steadily since the beginning of November. Stocks are, however, exceptionally high.

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BANANAS.—Jamaicas are quoted at £21 5*s.* per ton delivered London, and £21 nearest railway station. Brazilians are in good demand at £18 delivered nearest railway station.—(*West India Committee Circular*, 22nd December.)

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*
25th Nov. ..	5.44	7.56
2nd Dec... ..	5.30	7.09
9th Dec. ..	5.04	6.77
16th Dec. ..	5.26	7.13
23rd Dec. ..	5.07	—
30th Dec. ..	5.25	—
6th Jan... ..	5.33	—
13th Jan. ..	5.20	—
(15*th Jan.*, 1932) ..	5.41	7.25

To the general surprise the market has shown a very steady tone in spite of the international political situation and the unexpectedly larger increase in the Bureau crop estimate. After a sharp decline Egyptian has shown a better tone.

* * *

GRAPEFRUIT.—Average prices ruling in Covent Garden last week-end for popular sizes, 80's/126's were :

	s.	*d.*		*s.*	*d.*
Trinidad	22	6	to	25	0
Jamaica	14	0	to	15	0
Florida	20	0	to	21	0

—(*West India Committee Circular*, 22nd December.)

* * *

COFFEE.—Since the beginning of December prices have shown a tendency to rise, there being a particularly good market for Costa Rica and British East African sorts. Sales have included Costa Rica from 62*s.* to 110*s.* per cwt., Kenya 69*s.* to 128*s.* 6*d.*, Nyasaland 60*s.* to 73*s.*, and Rhodesia 66*s.* to 72*s.*

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COPRA.—Copra is quiet with West Indian f.m.s. lower at £15 net London.—(*West India Committee Circular*, 22nd December.)

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RUBBER.—Quotations for Plantation have ranged as follows :—

30th Nov.	$2\frac{5}{8}$
7th Dec.	$2\frac{9}{16}$
14th Dec.	$2\frac{15}{32}$
21st Dec.	$2\frac{15}{32}$
28th Dec.	$2\frac{7}{16}$
4th Jan.	$2\frac{13}{32}$
11th Jan.	$2\frac{7}{16}$
(13*th Jan.*, 1932)	$3\frac{1}{8}$

Conditions on the rubber market have been quiet with prices sagging slightly. The statistical position of the article is slowly but steadily improving, consumption in the U.S.A. being slightly better than anticipated while shipments from producing countries continue to decline. At a recent meeting of Malayan Rubber Growers a resolution was passed petitioning the Government to reopen negotiations with the Dutch and other Governments for the institution of international control.